## SPECIAL COST REPORT


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OIL, GAS AND PETROCHEMICAL PROCESSING

# Petroleum Refiner

JULY
1960


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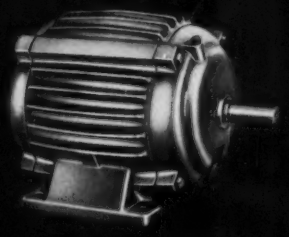

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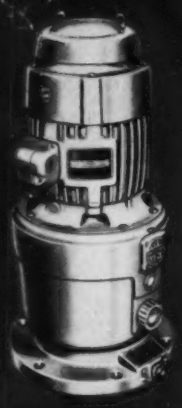

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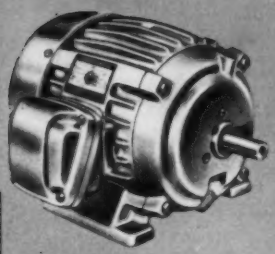

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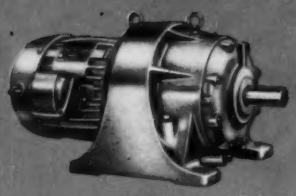

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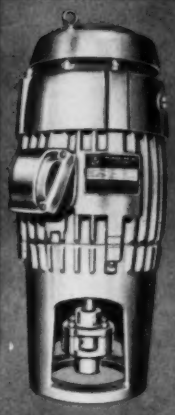

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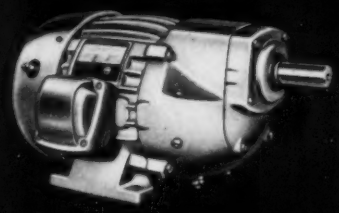

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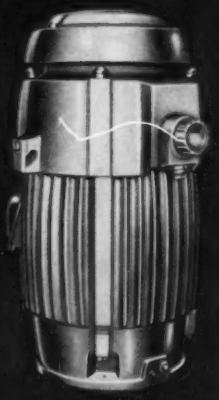

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Volume 39, No. 7 July 1960

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Petroleum
Refiner
OIL, GAS AND PETROCHEMICAL PROCESSING
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# A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

## SPECIAL COST REPORT

☐ **How Raw Materials Affect Costs . . .** Here's a useful tool for determining the fair costs for starting materials. You'll find how this engineering method can help you in controlling manufacturing costs by turning to **Page 108.**

☐ **How to Control Total Costs . . .** If you want to control manufacturing costs, break them down into variable cost and two types of fixed costs. See how this can apply in your plant, turn to **Page 112.**

☐ **How to Determine Low-Temperature Storage Costs . . .** Storage of LPG in flat-bottom domed-roof tanks at reduced pressure and temperature can be the most economical type of storage. You'll be able to use these data, derived from extensive computer studies, for evaluating optimum storage conditions. **Page 115.**

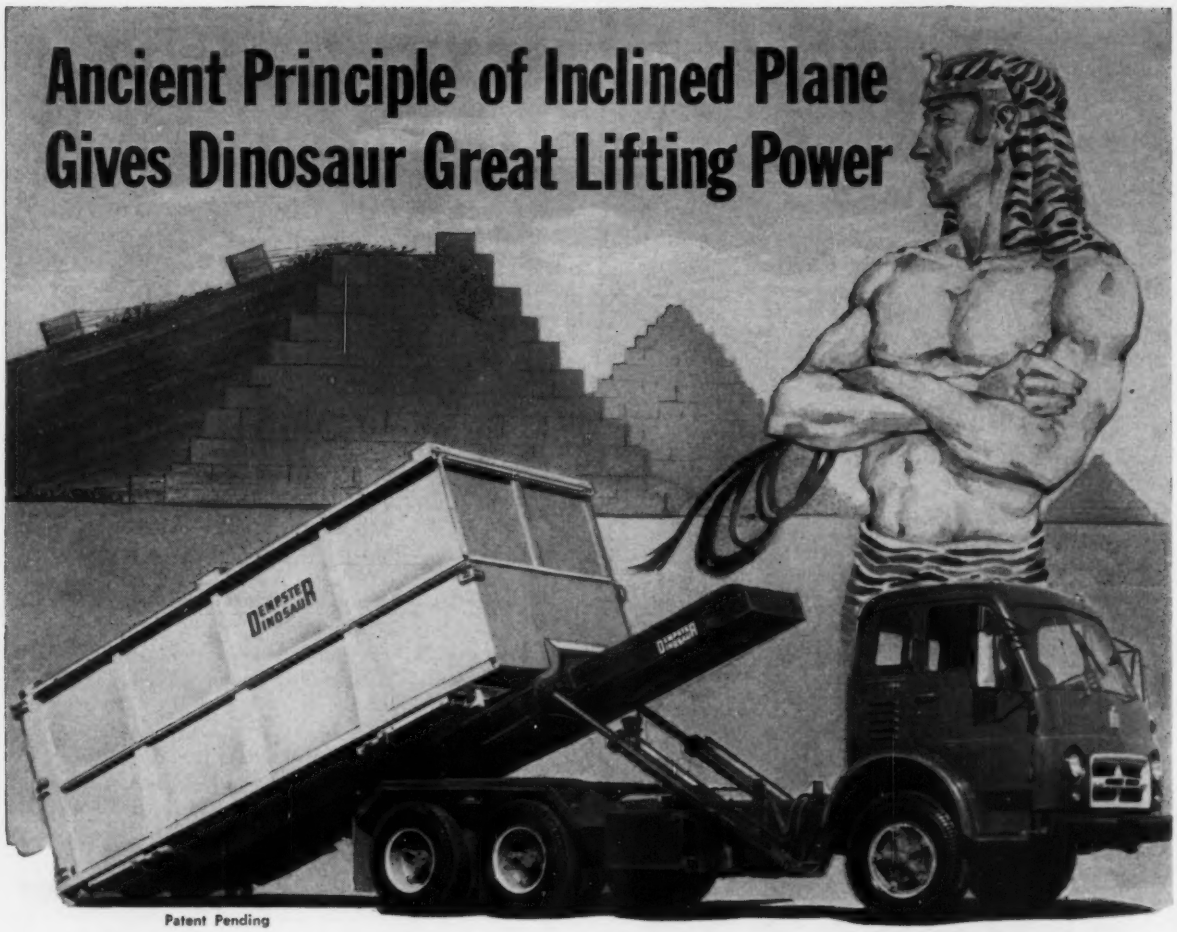
☐ **How to Estimate Fractionating Column Costs . . .** Use these charts, nomograms and data to estimate quickly the installed costs for complete fractionating columns. Turn to **Page 119.**

☐ **A New Feature . . .** Beginning in this issue is a new feature—Industry Quiz. It's a set of thought-provoking questions based on this issue of PETROLEUM REFINER. After you've read the informative articles listed at the left, turn to **Page 18** and see how you fare. Or if you prefer to take a peek at the questions beforehand, they'll give you an idea of the valuable information in this and every issue of PETROLEUM REFINER.

☐ **Unusual Foundation Design For Tall Towers . . .** Phillips engineers faced several difficult conditions recently when designing a foundation for two tall fractionating towers. They had to cope with close

Please Turn Page ➔

# Ancient Principle of Inclined Plane Gives Dinosaur Great Lifting Power




Patent Pending

Use of an inclined plane is one of the world's oldest lifting principles. Huge earthen ramps, timbers, rollers and plenty of slave-power are reputed to be behind the secret of lifting the huge blocks of stone into place to form the pyramids of Egypt.

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## A Quick Look at This Issue . . .

centerline distances, high towers, weak clay soil, hurricane winds and yet design each tower to be structurally independent of the other and each self supporting. To see how they accomplished this foundation analysis and design, turn to **Page 103.**

☐ **Piping of Pressure Relieving Devices . . .** Here are practical design tips for the piping engineer in the installation of pressure safety valves and safety discs. You'll find details on inlet piping, discharge piping and support design. There is also a simple method for calculating reaction forces acting on the piping at the time of discharge. To check on the tips for these "fail-safe" devices, turn to **Page 127.**

☐ **Applied Hydrocarbon Thermodynamics (Part 19) . . . Generalized Correlation of Fugacity Coefficients for Hydrocarbon Mixture Components . . .** Making use of some recent correlations which include the boiling point ratio, Professor Edmister now presents a master generalized correlation for fugacity. He covers a great deal of the past work in this field so you can get up-to-date with ease. Just turn to **Page 133.**

☐ **How to Check the Russian Literature . . .** You'll want to scan this list of Soviet publications, most of which are available in English translations. Turn to **Page 143.**

☐ **Corrosion Measurement Short Course (Part 3) . . .** Parts 1 and 2 showed you how to measure corrosion and determine the damage done to process equipment. This final part of the series delves into the causes of corrosion damage. Thus, the corrosion engineer has at his command the means to measure the corrosion taking place in his process stream, the tools and techniques to inspect for corrosion damage, and the methods available for investigating the causes of corrosion damage. For a look at how you can check on the causes of corrosion damage, turn to **Page 145.**

☐ **Use Computers to Select Exchangers . . .** If your company still sizes heat exchangers by hand, you will want to review this article. It will help you decide whether or not a digital computer is worth its cost. There's a sample program to show you the steps you would take in rating a typical exchanger, so turn now to **Page 149.**

☐ **Operator's Handbook for Gasoline Plants . . .** This part on fire fighting and emergency systems explains the equipment used as hand extinguishers and cart extinguishers. There are also outlines of shutdown systems, so be sure you turn to **Page 157.**

☐ **Add Oxygen for Better Cat Operation . . .** When catalytic cracking operation is limited by regeneration capacity, consider oxygen enrichment of the regenerator air to get better carbon burn-off. Here's an article which shows you how the technique works. **Page 161.**

☐ **Cut Your Drafting Costs With Photo-Drawings . . .** Use your plant darkroom and a reproduction machine to make photo-prints. A small amount of drafting completes the drawing for a plant revision at a fraction of the costs required to revise old tracings. And with a photo-drawing costing as little as $3.70 each (less than an hour's drafting time) real savings can be made. To see how to set up the system for your plant, turn to **Page 164.**

☐ **Find Viscosity of Liquid *n*-Pentane . . .** This useful nomogram, based on current data, permits accurate determination of viscosity over a wide range of temperature and pressure. Here's another sheet for your notebook so turn to **Page 167.**

☐ **New Charts Speed Drum Sizing . . .** offers a graphical method that is fast and accurate enough for preliminary estimates. You'll want to clip this article and hang on to it for a long time, so turn now to **Page 168.**

☐ **How Power Affects Human Behavior . . . Applied Group Dynamics: Part 3 . . .** In some situations a supervisor should exercise absolute control over a subordinate—at times the reverse is true. Most often, however, each must give and take a little to achieve the proper balance within the power spectrum. This is a true test of leadership as you will find from reading this interesting and informative article starting on **Page 175.**

☐ **Six Ways to Promote Safety . . .** Stimulating interest in a plant or company safety program is a never-ending job. So here are six good ideas which will help keep your safety interest alive. Be sure you read this interesting and informative article which starts on **Page 180.**

☐ **How to Develop First-Line Supervisors . . .** You can have strong first-line supervisors in your plant through careful selection, orientation and development. Here's how to pick the right man for the right job—plus what to do with him and how to handle him when he gets there. Turn now to **Page 184.**

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# We Go with HPI

The term HPI (hydrocarbon processing industry) was introduced in our April issue in an article by Dr. John McKetta, chairman of PETROLEUM REFINER's Editorial Committee, and also chairman of the Department of Chemical Engineering of the University of Texas, Austin. It caught on at once primarily because there never has been a quickly recognizable term that adequately describes the interest of those engaged in hydrocarbon processing. Certainly CPI would not do.

Ours was the first magazine to specialize in coverage of HPI; in fact, since August 1942 we have proclaimed from our front cover that we were dedicated to the interests of those engaged in refining, petrochemicals and natural gasoline. And, of course, since 1920 PR has been THE specialized magazine for petroleum processing.

Now with this new term, PR will cover coal chemical processing and other developments in hydrocarbon technology. "HPI" thus represents nothing radically new but is merely a handy tag for an industry that has made mighty progress in the past 15 years and yet stands to effect even more spectacular development in the immediate future. As Dr. McKetta pointed out in April, HPI "is the most progressive and still has the highest capital expenditure of any manufacturing industry."

So the prospects for our HPI are that its sparkling postwar performance will, if anything, be surpassed during the next decade despite a few pessimistic mutterings that are being heard in some financial and other circles.

# New Quiz Show

WE'RE SPONSORING a quiz show! And we feel sure it won't be rigged, because the judge, contestant and MC are you. The new show, which we call Industry Quiz (IQ for short) starts on Page 18. The questions were dreamed up by staff members after carefully reviewing feature articles in the current issue.

We tried not to pick the most obscure facts, but rather to pick questions which have general validity. You'll probably want to wait until you've read the issue before testing yourself. However, we won't consider the quiz rigged if you take the quiz now before you read any of the feature articles. Don't feel bad if you flunk it; with specialization so important today, it would be unusual if you knew about every field of interest covered in this quiz. Anyway, you don't have to tell anybody your score.

If you like this new feature, we'll try to continue it in every issue.

---

**Reprints** of the thermosiphon reboiler article ("How to Design Thermosiphon Reboilers" by Dr. James R. Fair) that appeared in our February issue are available to readers who would like to add it to their reference file. Address Editorial Director, PETROLEUM REFINER, Box 2608 and a copy of the 20-page discussion will, as long as the supply lasts, be sent you free.

# WHAT'S 1 OUT OF 1000 TO YOU?

**In cat cracking, minute percentages in the collection efficiency of catalyst recovery systems can make the difference between an economical and a completely undesirable operation. One tenth of 1% loss in efficiency in a large cat cracker can result in an increased carryover of more than 70 tons of catalyst per day. At $250 a ton, this can amount to over $17,000 . . . a lot of reason to specify the most efficient system . . . Buell Cyclones. Only Buell Cyclones have the exclusive Shave-Off that guarantees the extra efficiency necessary for continuous high-recovery results. And only Buell has the accumulated know-how derived from more than 25 years of experience in hundreds of refinery installations. Buell Engineering Co., 123 William St., New York 38, N. Y. Northern Blower Division, 6409 Barberton Ave., Cleveland, Ohio. (Subsidiary: Ambuco Limited, London, England).**

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# Quick Look at Industry...

**Castro Grabs Cuban Plants . . .**

Texaco, Shell and Esso plants now in Cuban hands after refusing to process Russian oil. As result, other oil companies won't fuel Cuban Airline planes—many suppliers won't ship exploration and drilling equipment and refinery replacement parts.

**If TML is Old—Why Recent Interest? . . .**

Tetramethyl lead now generally conceded as better than TEL because of aromatic content, lead content, and octane number of present fuels. But according to Ethyl report before SAE, this situation didn't exist when the two were first compared.

**Latest Logging on Smog . . .**

Jet aircraft not contributing to smog in Los Angeles Basin according to reports from Air Pollution Control District. Dense smog during take-off doesn't exceed legal limits.

Another smog note: retail gasoline vendors as well as suppliers responsible for complying with new L.A. County gasoline composition law effective July 1. Violators face 6 months imprisonment plus $500 fine for each day of offense. Results: refiners in L.A. area reducing bromine number of fuels to below the 30 mark.

**Petrochemicals Getting Naphthalene Market . . .**

With 3 new entries (Ashland, Collier-Tidewater, Sun) into naphthalene-from-oil field, petrochemical's share of this market should reach 225 million lbs. by '61. Stimulating the program are increased demand for phthalic anhydride, coal tar production sag, and declining imports. Of course, phthalic anhydride demand is expected to rise even higher, and in view of the slump in the coke-steel industry, the napthalene-from-coke picture is far from bright. On top of this, European naphthalene demand has sharply curtailed U.S. imports. Thus, don't be surprised if petrochemicals come close to capturing one-third of this market soon.

**Threaten Picketing at Texaco . . .**

OCAW international representative says union will picket Texaco's Pt. Arthur plant unless company stops supplying feedstocks to Jefferson Chemical at Pt. Neches. Chemical firm shut down about 8 weeks ago after being struck by union. Recently, however, company began operating with managerial personnel.

**New Imports Administrator . . .**

Lawrence J. O'Connor, Jr., takes over as Oil Import Administrator from Capt. Matthew V. Carson. O'Connor has been asst. director of office of Oil and Gas—Carson will continue to serve as director of this office.

**New Carbon Disulfide Process . . .**

Taylor Fibre has new process which employs liquid petroleum fractions instead of conventional methane gas for carbon disulfide production. Studies show new process will reduce plant investment by 25%; production cost by 15%.

Also making an appearance is Scientific Design's new process for making phenol by direct oxidation of benezene. SD claims low capital investment plus no by-products.

**More Refining South of the Border . . .**

Latest estimates say refining capacity in Latin America will increase 50% by 1969. Number of plants will grow from 70 to 90—average plant will spend $2 million to meet capacity and quality requirements. Petrochemicals will develop along same lines as in U.S.

Quick Look at World-Wide Construction . . .

Signal Oil & Gas starting to rebuild former Hancock refinery on Signal Hill near Long Beach. Damaged by fire in '58, expected capacity by year's end is in 15,000-to-20,000-bpd range . . . British Petroleum's first refinery in North America now onstream. Location: Ville d'Anjou, east of Montreal. Capacity: about 25,000 bpd . . . Parsons will design and build Saudi Arabia Refining's 20,000-bpd plant. Completion slated for late '62 . . . Shell will construct natural gasoline and propane recovery plant at mouth of Mississipi. Using refrigeration for separation, plant will handle 75-80 MMcf gas daily.

Venezuela Warns Cuba . . .

Venezuelan oil minister warns Cuba it may have trouble getting Venezuelan oil in the future if it cuts back purchases now. Warning was also implied to Britain which is now considering buying Russian crude.

Socony Gets Petrochemical Wing . . .

Socony Mobil's new operating division, Mobil Chemical Co., will carry on broad-scale petrochemical activities in U.S. and abroad. Will be responsible for all petrochemical plants built or under construction—including world's largest (380 million lbs. yearly) high purity ethylene plant now being built at Beaumont, Texas.

Financial note: sale of chemicals and related products now accounts for about $90 million of Socony's annual gross income.

India Eyes Liquid Coal . . .

Indian Institute of Technology now studying possibility of making liquid fuel from low-grade coals and blast furnace gases. Institute's chemical engineering department designed and built 100 gallon-a-day pilot plant.

Helium Gets Tentative O.K. . . .

Senate Interior Commission tentatively O.K.'s House-passed bill for long-range helium conservation plan. Amendment says private producer without government contract can sell helium at any price —— but those holding government contracts can't sell excess to "civilian" markets at less than they sell to government.

Quick Look Around the Country . . .

Tidewater President Getty says domestic oil consumption will continue to increase 1,000 barrels daily for foreseeable future . . . Latest API estimate says by 1975, number of motor vehicles in U.S. will reach 110 million—compared with 70 million today . . . Federal Power Commission, 5 years behind in rate cases, will take a month off . . . Americans drove nearly 700 billion miles last year.

Synthetic Rubber Use Bounces Higher . . .

Use of synthetic rubber in U.S. continues to rise with latest estimates shooting for 1.1 million long tons this year——up 4.5% from previous record high in '59. Because of this, one expert predicts natural rubber use will decline by 1 or 2%.

On the Political Front . . .

Notes from politics: Nixon goes on record as being in favor of natural gas bill and continued 27½% depletion . . . Lyndon Johnson continues to speak out for depletion allowance . . . John Kennedy publicly announces his support for National Fuels Policy study . . . more on politics on page 13.

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- a tube with a new concept of quality designed specifically for economical long life in heat exchangers

B&W Job-Matched LECTROSONIC Heat Exchanger Tubes are available through a nationwide network of district sales offices and steel service centers. And remember — matching tubes to jobs assures you the *right tube*, in the *right quantity*, at the *right time*. For more information call your local B&W District Sales Office, or write for Bulletin TB-431. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

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Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

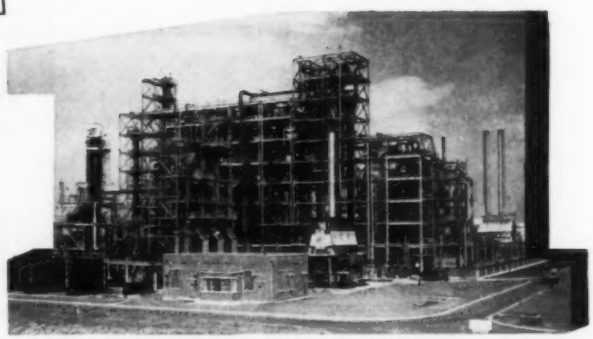


For more data on advertised products, use Readers' Service Cards, last page.

# KELLOGG BUILDS FOR I.C.I. EXPANSION

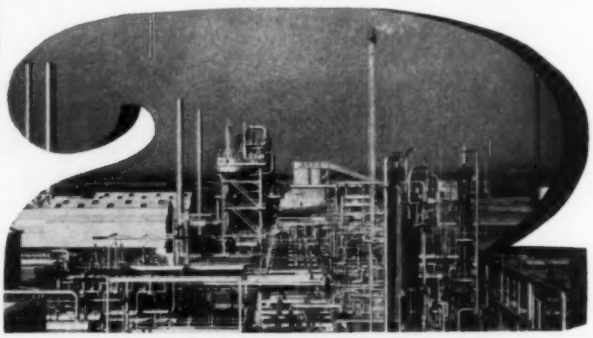
**1951**

Recent completion of Imperial Chemical Industries' third olefin plant at Wilton, England, has made these Works the largest petrochemical venture outside the United States. With a current output of 110,000 tons per year of high-purity ethylene, and a potential output of 140,000 tons, I.C.I. Wilton is an outstanding example of engineering cooperation.



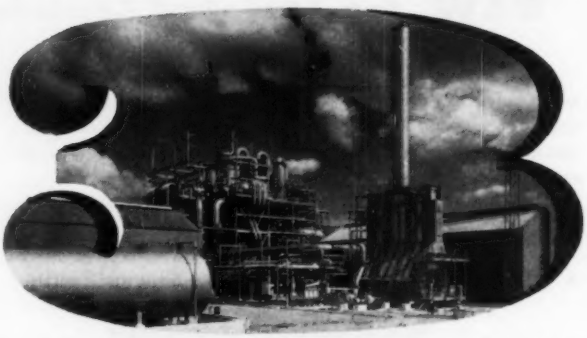
**1956**

The first plant was commissioned in 1951, and was the first full-scale adoption of the then novel process of oil pyrolysis developed in the Kellogg Laboratories. Its success led to the addition of No. 2 plant in 1956, and then to this latest extension, representing a 60% increase in olefin capacity, in 1959.



**1959**

Cooperation between client and contractor is the keynote of Kellogg's contribution to chemical engineering. The Wilton Olefin Plant is the largest in the world based on liquid feedstock. Kellogg is proud to have been associated with its development.



*To learn more about Kellogg's background in engineering and building olefin plants, at home and overseas, write for current Kelloggram*

**THE M. W. KELLOGG COMPANY**

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# Hoisting Your Political I.Q.

WITH THE PRESIDENTIAL ELECTION only four months off, it is a good idea for oil men to stand off and take a look at the big picture—to take a look at both parties and their leaders to ascertain just how they stand on issues vital to our industry. One thing we must keep in mind, and that is although only one man from each party can be nominated, we should not write off the others as has-beens. Quite the contrary. Most will continue politically potent and no doubt fill function in ways that will influence policies of their parties.

This is not a detailed study of each aspirant. Rather, a skimming in order to present points which should interest oil men. First let's look at the Republicans.

**Richard Nixon.** It's pretty well agreed that the Vice President will be nominated. Since becoming Vice President, this Californian has taken positions more liberal on some issues than when he served in the House and the Senate. Although he was absent on some key roll calls, his congressional voting record was favorable to the oil and gas industry including one vote for the natural gas bill. Just last month he came out in favor of the Harris Natural Gas Bill and a continued 27½ percent depletion allowance, thus he is regarded as friendly by the oil and gas industry. He is 47 years old, was elected to the House in 1946, to the Senate in 1950, and to the vice persidency in 1952.

**Nelson Rockefeller.** This is the only other Republican even remotely mentioned for the nomination. As a young man Rockefeller worked for the Creole Petroleum Co., learning the oil business. He has devoted most of the rest of his time to public affairs, serving in many positions with the Roosevelt, Truman and Eisenhower administrations. Generally, oil men know him as a political friend, due to his public statement in favor of the present oil depletion allowance. Born in 1908, Rockefeller was elected governor of New York (his first try) in 1958.

On the other side of the ledger, Democratic hopefuls are plentiful. It's possible that by the time you get this issue of PETROLEUM REFINER, the Democrats meeting in Los Angeles will have settled on a candidate. To repeat, however, the others will continue to be politically effective, and for this reason we should consider their background and feelings toward the oil industry. Here's the alphabetical listing:

**Hubert Humphrey.** Immediately following his 1948 election, this Minnesota Senator earned a reputation as an outspoken left winger. Since then, he has quieted down some and has softened his views, but the first impression has remained for many. His voting record is decidedly anti-oil and anti-gas, and although he withdrew several months ago as an active candidate for the nomination, he remains a Vice Presidential possibility.

**Lyndon Johnson.** Democratic leader of the Senate since 1953, Lyndon Johnson has a 100 percent pro-oil and pro-gas voting record. And because of this he has been ridiculed by syndicated columnists and liberal organizations. For more than 12 years he has been one of the most effective behind-the-scenes operators in behalf of oil and gas legislation. The Texan was elected to the House in 1937 and to the Senate in 1948.

**John Kennedy.** Son of the wealthy Joseph P. Kennedy, who has many close friends in the oil industry, this Senator has been a foe of the natural gas bill and other major oil and gas issues. A cum laude graduate of Harvard, with subsequent study at the London School of Economics, he intended to be a writer and won the Pulitzer Prize for his book, "Profiles in Courage." In 1946, however, he turned to politics by running successfully for the House. Then in 1952 he moved up to the Senate with his spectacular defeat of Henry Cabot Lodge, Jr. He was born in 1917.

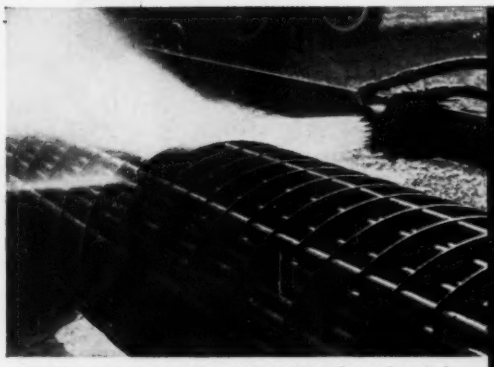
**Stuart Symington.** His speeches deal almost exclusively with national defense, the subject on which he is best informed. The Missourian held a number of high government jobs prior to his 1950 election to the Senate. Born in 1901, his voting record is rated more favorable to labor than to business.

**Adlai Stevenson.** Looming once more as a possible nominee, this two-time loser has yet to make his views on industry issues clear. In his previous campaigns, he received little oil industry support, but according to polls, he still retains a large following within his party. Born in 1900, he served one term as Illinois governor, and has since been practicing law in Chicago, traveling the globe, and making speeches.

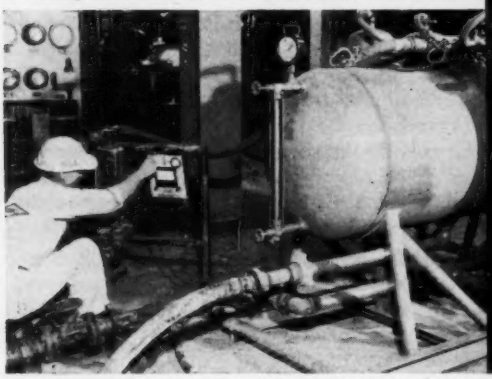
Those are the ones seeking the No. 1 position.

In addition, however, 33 Senate seats will come up for grabs in November, with only 30 of these Senators running for re-election. Let's take a look at how they voted on four key oil and gas issues. Votes "for" in the first two columns and "against" in the last two columns constitute votes in favor of

## *A new mark for a nation-wide cleaning service . . .* DOW



Jetting tool cleans tubes fouled with coke and asphalt.



New mobile foam-cleaning equipment cuts cleaning costs.

Cleaning missile lines and components requires tolerances as close as 150 microns.

# DOW INDUSTRIAL SERVICE

**Industrial Cleaning.** Dow Industrial Service, now a separate division of The Dow Chemical Company, offers the only nation-wide chemical cleaning service for virtually all types of industrial processing equipment. This is an expansion of the cleaning service developed over the past 20 years. Dow is currently servicing entire plants as well as doing special cleaning jobs for both large and small companies.

Dow Industrial Service research in industrial chemical cleaning has developed specialized mobile equipment and techniques, some of which are pictured above. These highly efficient techniques are improving plant productivity and reducing equipment downtime in all industries using steam generators, condensers, heat exchangers, towers, water and product lines, water wells and tanks, or similar process equipment.

**Product Sales and Service.** The sale of specialized chemical products, scientifically formulated to be of use in specific industrial processes and to give the necessary technical service in their use, is the job of Product Sales and Service. Purifloc* N17 is an outstanding new flocculant cleared by USPHS for use in potable water.

**Laboratory Service.** Because of the rapid development of chemical products for the municipal and industrial waste and water treatment areas, Dow Industrial Service will take on the service-selling of those products. Also, a consulting laboratory service for municipal and industrial waste and water treatment is provided.

**You'll find Dow Industrial Service offices and stations with specialized cleaning equipment and experienced personnel in all major industrial areas. For more information, write to Dow Industrial Service, 20575 Center Ridge Road, Cleveland 16, Ohio.** *TRADEMARK

**DOW INDUSTRIAL SERVICE** DOW *Division of THE DOW CHEMICAL COMPANY*

the oil industry. Conversely, votes "against" in the first two columns and "for" in the last two denote votes against the oil industry.

**Chart 1**

| SENATOR | Kerr Bill To Amend Natural Gas Act (3/29/50) | Harris Bill To Amend Natural Gas Act (2/6/56) | Williams Amendment To Reduce Depletion Percentage From 27% To 15% (8/11/58) | Douglas Amendment To Reduce Depletion Percentage On Graduated Basis (6/25/59) |
|---|---|---|---|---|
| Gordon Allott (D—Colorado) | * | For | Against | Against |
| Clinton P. Anderson (D—N. Mex.) | For | For | Against | Against |
| E. L. (Bob) Bartlett (D—Alaska) | * | * | * | Against |
| Styles Bridges (R—N. Hampshire) | For | For | Against | Against |
| Clifford P. Case (R—N. Jersey) | * | Against | For | For |
| John S. Cooper (R—Kentucky) | * | * | Against | Against |
| Carl T. Curtis (R—Nebraska) | * | For | Against | Against |
| Paul H. Douglas (D—Illinois) | Against | Against | Against | For |
| Henry Dworshak (R—Idaho) | Against | For | Against | * |
| James O. Eastland (D—Miss.) | For | For | Against | Against |
| Allen J Ellender (D—La.) | For | For | Against | Against |
| J. Allen Frear, Jr. (R—Del.) | For | For | Against | Against |
| Hubert H. Humphrey (D—Minn.) | Against | Against | For | For |
| Lyndon B. Johnson (D—Texas) | For | For | Against | Against |
| B. Everett Jordan (D—N.C.) | * | * | Against | Against |
| Estes Kefauver (D—Tennessee) | Against | Against | * | For |
| Robert S. Kerr (D—Oklahoma) | For | For | Against | Against |
| John L. McClellan (D—Arkansas) | For | For | Against | Against |
| Pat McNamara (D—Michigan) | * | Against | For | * |
| Thomas E. Martin (R—Iowa) | * | For | Against | Against |
| Karl E. Mundt (R—S. Dakota) | Against | For | Against | Against |
| Joseph C. O'Mahoney (D—Wyo.) | Against | For | Against | * |
| Jennings Randolph (D—W. Va.) | * | * | * | Against |
| A. Willis Robertson (D—Va.) | For | Against | Against | Against |
| Richard B. Russell (D—Ga.) | For | Against | * | Against |
| Leverett Saltonstall (R—Mass.) | Against | For | Against | Against |
| Andrew F. Schoeppel (R—Kan.) | For | For | Against | Against |
| Margaret Chase Smith (R—Me.) | Against | Against | For | For |
| John J. Sparkman (D—Alabama) | For | Against | Against | Against |
| J. Strom Thurmond (D—S.C.) | * | For | Against | Against |

* Did not vote, or was not in office at the time.
Footnote: 33 Senate seats will be open in November. However Theodore F. Green (D—R.I.), Hall Stoner Lusk (D—Ore.), and James E. Murray (D—Mont.), are not seeking re-election.

The Senator from your state, of course, should not be judged merely on the record of these four votes, but if you are going to be a politically informed citizen, you certainly should know how he feels about the industry most vital to you—the oil industry.

Last month (P. 13) you will recall we presented a quiz so you could test your own political I.Q. in the area of oil. Here are a few of the promised facts and figures compiled by the Texas Mid-Continent Oil & Gas Association from questionnaires filled in by more than 500 oil men in the middle-to-upper echelons of management:

1. Seventy-nine percent knew the name of their own Congressman—in other words, 1 out of 5 don't know. Twenty-three percent knew three members of the State Legislature, and 34 percent the name of their state senator. Thus, the state senator is unknown to two-thirds of the industry personnel represented in these meetings.

2. Seven percent said they had written a Congressman on the fuels policy issue; 11 percent on percentage depletion; 8 percent on natural gas regulation; 16 percent on labor legislation; 7 percent on gasoline taxation; 19 percent on any other subject.

3. Forty-three percent could report they had ever made a personal contribution of funds to a political party or candidate and 37 percent said they had ever worked as a campaign volunteer. In presidential elections 29 percent regard themselves as Democrats; 37 percent as Republican, and 32 percent as Independent.

4. Thirty-one percent claimed membership in local civic or service clubs.

5. Forty-four percent knew the total state and federal gasoline tax. Eleven percent knew the crude oil severance tax; 13 percent had correct number on the gas tax. (Many answers were "close" to correct.)

6. Listed below (identifications did not appear on quiz) are results of the question: "Generally, what attitude do you think the following persons have toward the oil and gas industry?"

| | Friendly % | Unfriendly % | Don't Know % |
|---|---|---|---|
| **Chet Huntley** (radio-TV news commentator) | 34 | 11 | 53 |
| **David Brinkley** (radio-TV news commentator) | 29 | 12 | 57 |
| **Douglas Edwards** (radio-TV news commentator) | 15 | 8 | 75 |
| **William Proxmire** (Sen., D-Wis., frequent critic of percentage depletion) | 1 | 61 | 37 |
| **Lyndon Johnson** (Sen., D-Texas) | 89 | 3 | 6 |
| **Dwight Eisenhower** (Pres. U.S.) | 72 | 12 | 15 |
| **Jerome K. Kuykendall** (Chmn. Federal Power Commission) | 19 | 14 | 65 |
| **Frank M. Porter** (Pres. API) | 63 | 4 | 32 |
| **Paul Douglas** (Sen., D-Ill., and frequent critic of percentage depletion) | 7 | 54 | 38 |
| **Drew Pearson** (syndicated columnist) | 4 | 67 | 27 |
| **Matthew V. Carson, Jr.** (administrator of oil imports program) | 43 | 7 | 48 |
| **Richard Nixon** (Vice Pres., U.S.) | 54 | 12 | 32 |
| **M. J. Rathbone** (Chmn. API; Pres. Standard of Jersey) | 57 | 1 | 41 |
| **Oren Harris** (Cong., D-Ark., sponsor of considerable legislation past decade to free gas producers of federal control) | 42 | 6 | 48 |
| **Ralph Yarborough** (Sen., D-Texas) | 42 | 39 | 17 |

**Now What?** That's the political climate for oil and gas as we head into the all-important November elections. After reading this and perhaps last month's editorials many a reader is better informed politically than he had been. It's up to the individual oil man to keep himself posted along these lines.

---

*Despite the inflation of which we are all so conscious, petroleum products are a bargain in price. One of my associates joined the oil industry in 1914, and he likes to keep track of what has happened since then. His figures show that the price of the industry's principal product—gasoline—is about 50 percent higher today than in 1914, compared with a rise of nearly 300 percent in the so-called cost of living index. In some countries, low-priced products reflect low-paid workers, but my associate's records show that wages in the U.S. oil industry are up 1,000 percent since 1914, and in addition petroleum industry employes are the recipients of fringe benefits of unequalled liberality.*

—Robert G. Dunlop, President
Sun Oil Company

# How premium blend stocks perform on the road

## Recent work by Ethyl Research pinpoints effects of component concentration and component boiling range on road performance

by **E. J. FORSTER,**
*Refinery Technology Division, Ethyl Research Laboratories, Detroit, Michigan*

THIS recent study, conducted by Ethyl Research for a specific refiner, produced two broad conclusions on the performance of premium gasoline components which are of interest to the entire refining industry:

**1.** Gains in Research octane number that are achieved through increasing the severity of catalytic reforming are not fully realized in terms of antiknock performance on the road.

**2.** When catalytic reformate is split and the bottom cut of the reformate is blended to premium gasoline, the wider the boiling range of the bottom cut, the better the road performance of the fuel relative to its Research octane number.

Ethyl Research was able to predict accurately the results of the study because increasing reforming severity also means increasing the aromatic content and, therefore, the fuel sensitivity (Research octane number minus Motor octane number).

### Why These Conclusions Are Important

Efficient use of high octane blending stocks is very important to the refiner because of the octane improvement costs of current premium gasolines.

Optimum antiknock quality must represent an economic balance between both Research octane and Road octane. This must be continually reviewed because of the alternate methods for octane improvement available to the refiner.

For example, one alternate is splitting certain stocks such as catalytically cracked naphtha and reformate. Fractionation facilities are best used for this purpose when the optimum boiling range to blend for road performance is known.

Similarly, it is helpful to know the effect of increased reforming severity upon road performance, the effect of the addition of alkylate upon road performance, the effect of boiling range of catalytic naphtha and other factors that affect premium quality.

### Ethyl's Test Program

Twenty-seven test blends were designed from base stocks shown in the opposite table to study various effects of base stock concentrations, reforming severity, and boiling range. Sixteen blends were composed of combinations of various catalytic naphthas and reformates. From these, two blends were selected because of their respective superiority with regard to either Road octane number or depreciation. Various percentages of alkylate, straight-run or polymer then were added to each of these reformate-naphtha base blends. Blends were leaded to a concentration of 3.0 ml TEL/gallon and butane was used to pressure blends to 10.0 lb. Reid vapor pressure.

Both Modified Uniontown and Borderline road ratings were conducted in three passenger cars.

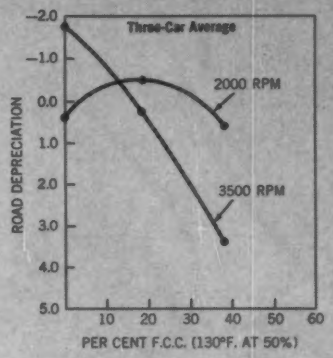
| 1959 VEHICLE | COMP. RATIO |
|---|---|
| A | 11.1-1 |
| B | 10.7-1 |
| C | 10.1-1 |


For more data on advertised products, use Readers' Service Cards, last page.

**BASE STOCKS USED AS COMPONENTS IN TEST BLENDS**

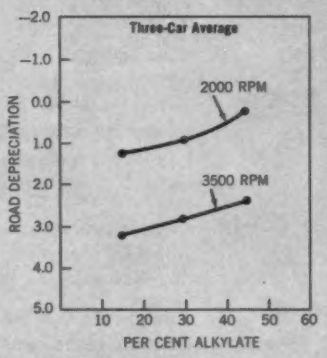
1. F.B. (Full-boiling) Cat Reformate (100 RON @ 3.0 ml TEL)
2. Heavy Cat Reformate (30% Bottoms, F.B. = 100 RON @ 3.0 ml)
3. Heavy Cat Reformate (70% Bottoms, F.B. = 100 RON @ 3.0 ml)
4. Heavy Cat Reformate (30% Bottoms, F.B. = 102 RON @ 3.0 ml)
5. Heavy Cat Reformate (70% Bottoms, F.B. = 102 RON @ 3.0 ml)
6. Light F.C.C. Naphtha (50% Evaporated @ 130°F)
7. Light F.C.C. Naphtha (50% Evaporated @ 180°F)
8. Full-boiling Alkylate
9. Light Straight-run
10. Catalytic Polymer

**Effect of 130° Cat Naphtha on the Road Depreciation of Full-Boiling 100 RON Reformate**



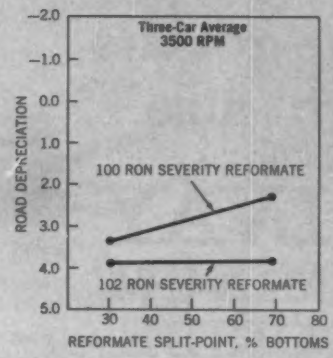

Up to 20% cat naphtha raised the low-speed (2,000 RPM) Road octane performance and consequently reduced depreciation (Research octane minus Road octane). At high engine speeds, the presence of cat naphtha in any amount results in depreciation which increases as the percentage of naphtha increases.

**Effect of Alkylate on Road Depreciation Base Blend Composition: 40% 180° F.C.C., 60%-30% Bottoms 102 Ref.**




The addition of alkylate reduces road depreciation and thereby emphasizes the important effect of sensitivity on road performance.

**Effect of Reformate Boiling Range and Severity on High Speed Road Depreciation**




At any given split-point a change in reforming severity from 100 to 102 RON results in greater depreciation at high speeds.


# How Ethyl Research works for you

Ethyl Research Laboratories in Detroit are continually investigating the variables that affect gasoline performance. Frequently, special studies are made for individual customers that are of interest to the entire industry.

An example is the new research report, "Road Antiknock Behavior of Premium Blends." This is available through your Ethyl Representative or send your request to: Ethyl Corporation, 100 Park Avenue, New York 17, New York.

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# INDUSTRY QUIZ

***Test your industrial IQ with this quiz on the current issue of PETROLEUM REFINER***

**1.** A good rule of thumb for sizing reflux drums is to assume that the length to diameter ratio is three. True or False?

**2.** Shop fabrication costs for carbon steel tower shell sections usually run (a) 25 to 40 cents per pound, (b) 50 to 65 cents per pound, or (c) 60 to 80 cents per pound?

**3.** A safety valve may be mounted either vertically or horizontally on a pressure vessel, if the connection between the valve and vessel provides direct and unobstructed flow. True or False?

**4.** In sizing an average heat exchanger, about how much faster is a digital computer than an experienced rating engineer doing it by hand. (a) 10 times (b) 1,000 times, or (c) 100,000 times.

**5.** What is the effect of enriching regeneration air for catalytic cracking to a concentration of about 27 weight percent oxygen—(a) increase in coke burning to 89 percent conversion, (b) much higher regeneration temperatures, or (c) increase in throughput of 23 percent?

**6.** Direct variable costs constitute the major portion of product cost. True or False?

**7.** Though photo-drafting is a faster means of getting information on record than standard drafting techniques, it does cost more. True or False?

**8.** The Soviet Union ranks (first), (second), (third), in world production of chemical literature?

**9.** If two tall towers having different natural vibration periods are placed on a common foundation, assuming aerodynamic vibrations to occur at both frequencies, impulses transmitted into the foundation by each tower would tend to be amplified. True or False?

**10.** Raw material costs are critical in superphosphate fertilizer plant operation. What increase in sulfuric acid cost results in a deficit operation—(a) 1 cent per pound, (b) 0.1 cent per pound, (c) 0.01 cent per pound.

**11.** If there is a critical material failure caused by corrosion, which of the following tests *may be omitted?*

a. Analyze deposits with X-ray diffraction techniques
b. Examine deposits under petrographic microscope to find types of compounds
c. Make spectrographic tests
d. Try X-ray fluorescence
e. Make analytical and micro-analytical chemical tests to find composition of deposits
f. Make metallographic examination of section from damaged part.
g. Mechanically test the part
h. Analyze the process fluid.

**12.** For propane tankage, above what capacity does low temperature storage become economical (a) 15,000 barrels, (b) 20,000 barrels, or (c) 30,000 barrels?

***Answers on Page 264***

Photographed at Shell Oil Company (Houston, Texas, Refinery)

## Cyanamid met a need... and produced the first successful 25% alumina catalyst

A few years ago, cooperation between a major refiner and Cyanamid went far beyond meeting the demand for continuously superior fuels. It developed a milestone in catalyst chemistry—fluid cracking catalyst AEROCAT TRIPLE A®, the first commercially successful 25% alumina catalyst.

AEROCAT TRIPLE A combines unusually high activity and stability for premium cracking efficiency. These properties provide high equilibrium activity and contribute to increased conversion at lower temperatures or reduced catalyst usage at severity levels required for low alumina catalysts.

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**Basic in catalyst chemistry**

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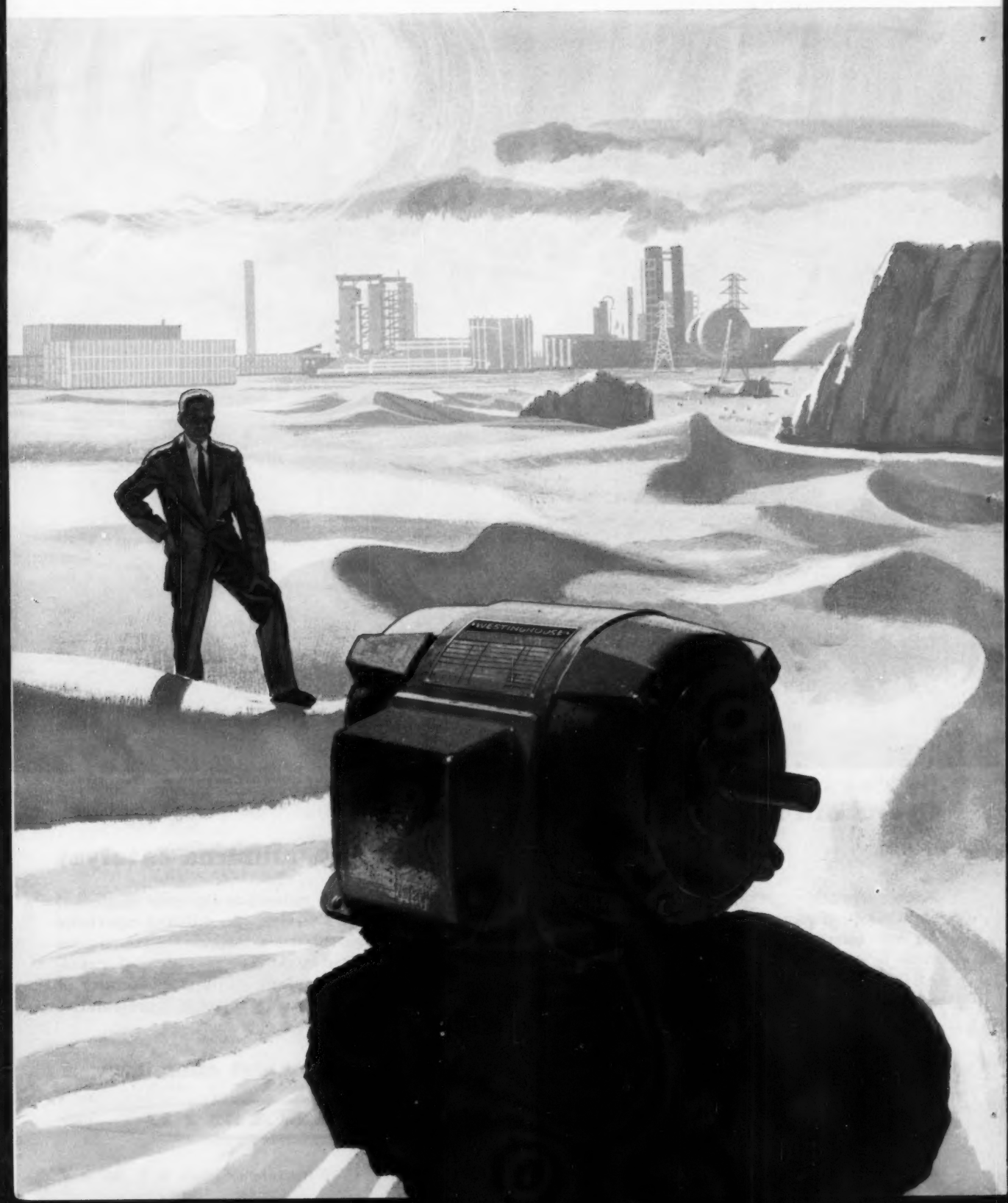
*New* *Guardistor*

# THE MAN & THE MOTORS



# FROM WESTINGHOUSE

## *Guardistor* motors let you match the full capability of the motor to the job— with complete safety—absolute confidence

**Our Marketing Manager says:**

- "You can match the motor to the load . . . use all the motor you are paying for.
- Provides positive protection based on winding temperature . . . *not* load current and/or power supply fluctuations.
- Eliminates time and expense of changing winter-summer heaters. No nuisance tripping, it's fail-safe . . ."

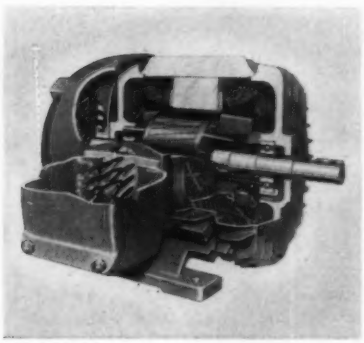
**Our Engineering Manager says:**

"With the breakthrough development of the Westinghouse Positive Temperature Coefficient thermistors, for the first time we can provide inherent protection against motor failure caused by excessive heat. The solid-state thermistors buried in the windings instantly sense excessive heat from any cause and simultaneously warn of trouble or automatically take the motor off the line. Thus, motor protection is placed where only true motor protection can be . . . in the windings."

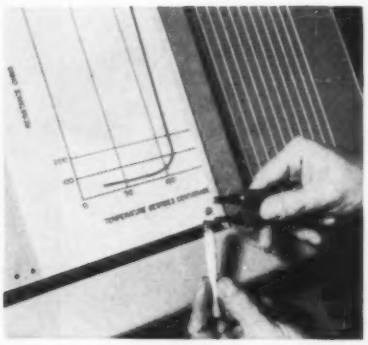
Call your Mr. Westinghouse for the application of a Guardistor* motor to your drive requirements . . . write for *Questions and Answers About . . . Guardistor* (B-7876). Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*Trade-Mark

J-22160



Unlike remotely located sensing devices, PTC thermistors are buried in the windings of the Guardistor motor, instantly equating all temperature factors.



Ever alert PTC thermistors constantly totalize temperature, statically triggering an action *only* if critical temperature is reached.

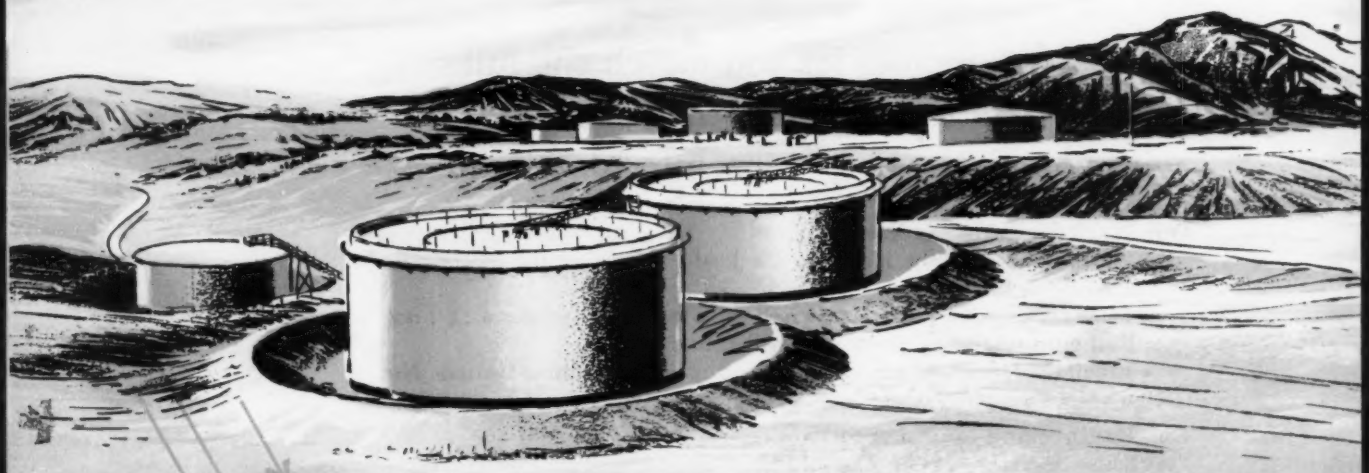
MOTOR & GEARING DEPARTMENT

**YOU CAN BE SURE... IF IT'S**

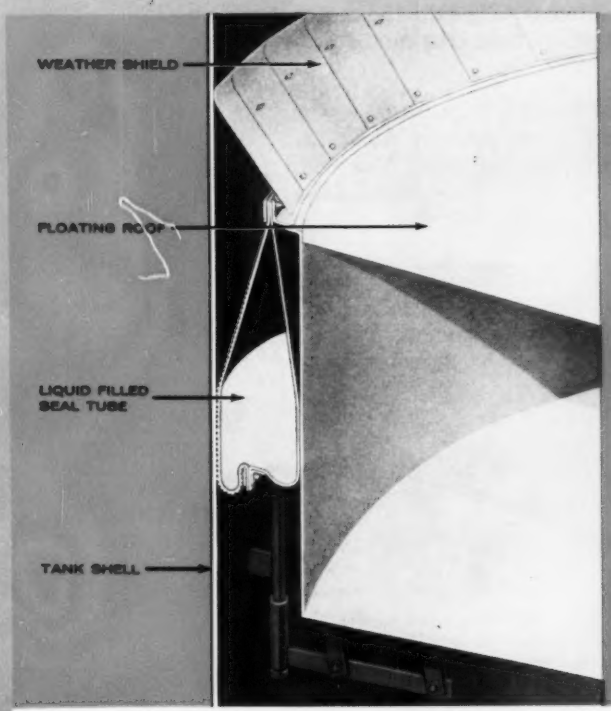
# Westinghouse

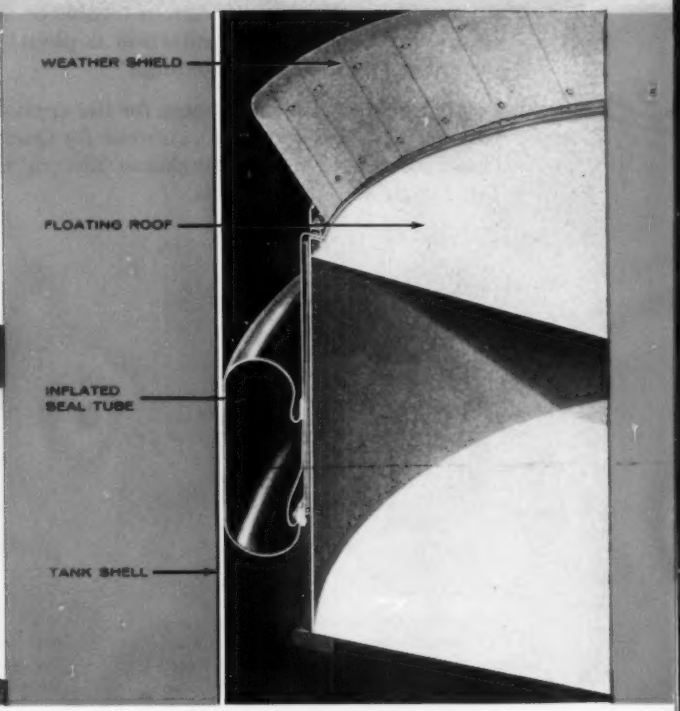
TUNE IN WESTINGHOUSE CBS TV RADIO COVERAGE, PRESIDENTIAL CONVENTIONS, JULY 10-29

# CB&I OFFERS THE



## FEATURES AND ADVANTAGES OF HORTON SEALS




### SR5 / HORTON LIQUID FILLED FABRIC SEAL

- Sealing liquid holds envelope against tank shell.
- Pressure against shell is greatest at bottom, decreasing to zero at top of contact.
- Flexible ring support provides adequate clearance and better fit for all rim space variations.
- Sealing band and rim band vulcanized at bottom connection.

### SR6 / HORTON INFLATED FABRIC SEAL

- Gas holds envelope against tank shell.
- Constant mild pressure, maintained by simple gasholder, over entire surface.
- Positive means of supplying seal gas.
- Maximum clearance to accommodate rim space variations due to badly out-of-round shells.
- Vulcanized to form endless tube.
- Can be serviced from top of roof.

# WIDEST CHOICE OF SEALS
## for Floating Roof Tanks

More CB&I-built floating roof tanks serve the petroleum industry than the total constructed by all other manufacturers. The reason . . . superiority of CB&I structures in design, construction and performance in reducing evaporation loss, retarding corrosion and minimizing fire hazard.

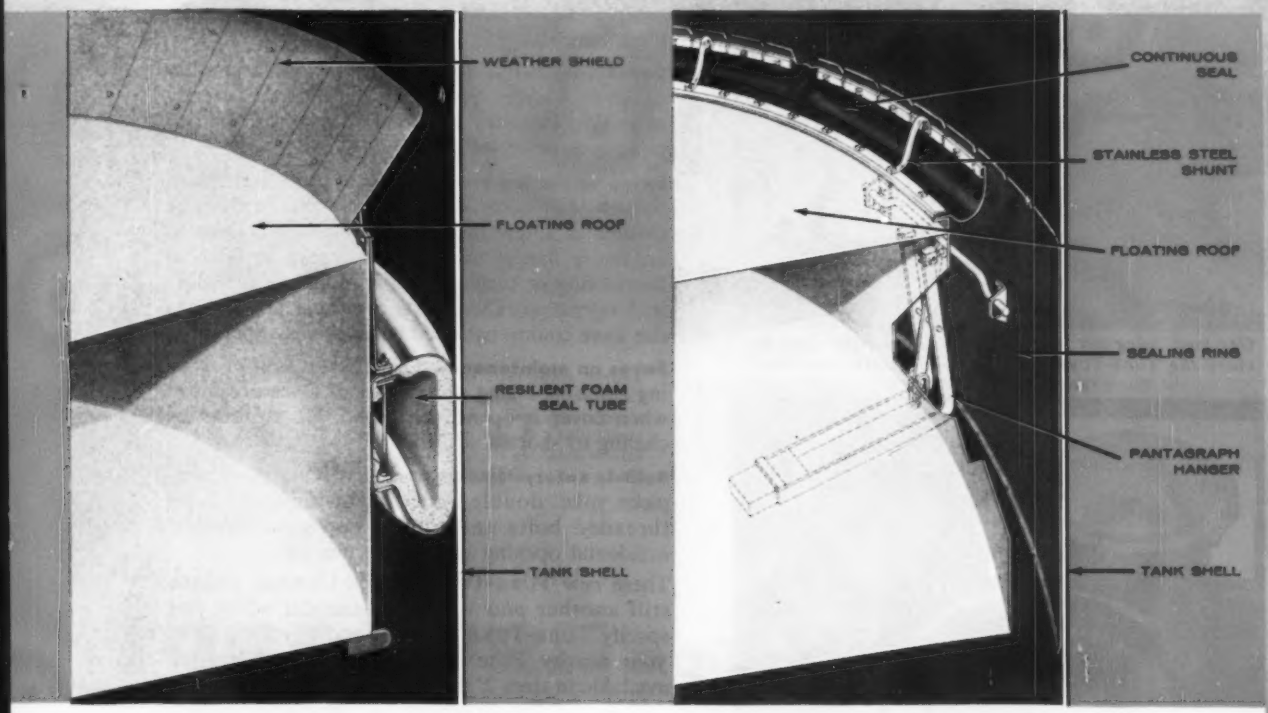
A key factor has been CB&I's continuous development of close-fitting, long-lasting Horton® Seals, which have set performance standards for the industry. Today, Horton Seals—both metallic and fabric—offer the widest selection of designs available anywhere.

CB&I's extensive experience (since 1922) with all types of sealing designs is at your disposal. For an accurate appraisal of the proper sealing mechanism for your specific storage conditions, call or write the nearest CB&I office.

**CHICAGO BRIDGE & IRON COMPANY**

332 SOUTH MICHIGAN AVENUE
CHICAGO 4, ILLINOIS

OFFICES AND SUBSIDIARIES IN PRINCIPAL CITIES THROUGHOUT THE WORLD




**SR7 / HORTON RESILIENT FOAM FABRIC SEAL**

- Resilient foam holds envelope against tank shell.
- Mild and positive pressure against tank shell.
- Maximum clearance to accommodate rim space variations due to badly out-of-round shells.
- Endless sheet covers resilient foam, forming tight envelope.
- Can be serviced from top of roof.

**SR3 / HORTON METALLIC SEAL**

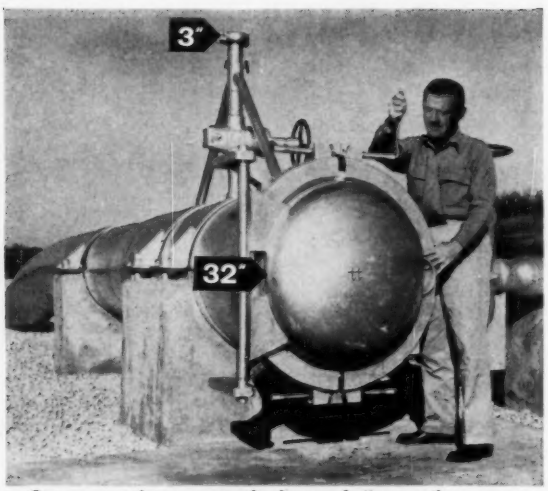
- Continuous steel sealing ring.
- Pantagraph hangers hold sealing ring against tank shell with minimum pressure.
- Hangers keep roof centered in tank.
- Continuous seal closes rim space.

*Horton Floating Roofs are covered by U. S. Patents and pending applications.*

P98SCB

# NEW...FROM TUBE

## an improved hinged closure for pipe lines, piping and process equipment




*One man, using any standard wrench, can easily open or close the* TUBE-TURN *Hinged Closure. Has important safety features, too!*

Tube Turns announces a new line of hinged closures with important advantages for pipe lines, piping and process equipment wherever frequent access is required or where the use of blind flanges would be cumbersome and time consuming. Proved in scores of applications by major companies, the unique TUBE-TURN* Hinged Closure provides these benefits:

**Saves installation time.** Light weight assembly easier to handle. Completely fabricated . . . ready to install. Requires only one butt-weld to join to pipe, tank or vessel opening.

**Saves operating cost.** One man, using a standard wrench, can easily open or close the largest size closure in a few minutes. No threads or lugs to engage or flanges to line up. No parts to fail. No hammering or tugging. Can be adapted to motorized operation. Closures for vertical applications can have counterbalanced caps for easy operation.

**Saves on maintenance.** Oil resistant, self-energizing static "O" ring provides seal. Does not move when cover is opened or closed. No rubbing or chafing to shorten seal life.

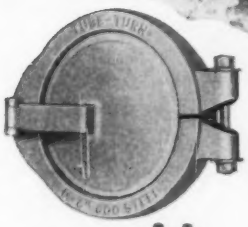
**Built-in safety.** Exclusive design features of two-piece yoke, double-ended right- and left-hand threaded bolts and hinged cap guard against accidental opening under pressure.

These new TUBE-TURN Hinged Closures provide still another *plus value* you can get when you specify TUBE-TURN products and buy them from your nearby Tube Turns' Distributor. They are available in sizes 2" through 42" for A.S.A. 150-lb, 300-lb and 600-lb service . . . in steel or alloys.

*"TUBE-TURN" and "tt" are trademarks of Tube Turns.

*For vertical applications,* TUBE-TURN *Hinged Closures can be equipped with spring-loaded, counterbalanced caps.*

# TURNS...



*Above:* 32-inch TUBE-TURN Hinged Closure. This type with right-and-left hand threaded yoke bolts is available in sizes 8" thru 42". *Left:* Single bolt type closure is available in sizes 2" thru 8", removable or swing bolt.

*Another* tt *plus value from...*

# TUBE TURNS

DIVISION OF CHEMETRON CORPORATION

**Louisville 1, Kentucky**

CHEMETRON

DISTRICT OFFICES: Atlanta • Buffalo • Chicago • Columbus • Dallas • Denver Detroit • Houston • Kansas City • Los Angeles • Midland • New York Philadelphia • Pittsburgh • Richmond • San Francisco • Seattle • Tulsa

*In Canada:* TUBE TURNS OF CANADA LIMITED, Ridgetown, Ontario
*District Offices:* Edmonton • Montreal • Toronto

*In Mexico:* TUBE TURNS DE MEXICO, Mexico City

**FREE BULLETIN**... Complete information on the new line of TUBE-TURN Hinged Closures will be sent on request. Mail coupon.

**TUBE TURNS, Dept. PR-7**
**224 E. Broadway • Louisville 1, Kentucky**

Please send Bulletin TT956 on new TUBE-TURN Hinged Closures.

*Company Name* _____

*Company Address* _____

*City* _____ *Zone* ____ *State* _____

*Your Name* _____

*Position* _____



For more data on advertised products, use Readers' Service Cards, last page.

*Here's Why*
*Oil Men Specify—*

# EC&M
## HIGH VOLTAGE STARTERS

**2200-4800 VOLTS**
FOR
*PRESSURIZED ROOMS*
*OUTDOORS*
*INDOORS*

*left* • Type AH Starter (50,000 KVA, certified) for Division 2 Applications. NEMA 3R (raintight) Enclosures for mounting outdoors
*below* • Diesel loading pump station in southwestern refinery

EC&M Starters are standardized for *easy selection.* They are *easier to install* because they are shipped with all internal wiring complete. They are designed for *easier, faster inspection and maintenance.* And—they *save valuable space* because they are compact with no sacrifice in accessibility.

EC&M's Type AH Starters are available in NEMA 1 or 3R (raintight) enclosures for outdoors, indoors or pressurized control rooms. Three interrupting ratings: 50,000 KVA—POWER FUSED—and VALIMITOR®

***Write* for Bulletin 8130**

Five EC&M Aligning Starters with Incoming Line and Feeder Panels for Pumps and Compressors (Pacific Coast Refinery)

Pressurized Control Room with ten NEMA 1 EC&M Enclosed Starters in midwest refinery

SQUARE D COMPANY
EC&M DIVISION • CLEVELAND 28, OHIO
***wherever electricity is distributed and controlled***

8019

## SIMPLY DO THIS!

One easily assembled, self-aligning split sleeve coupling connects drive shaft and stirrer shaft.

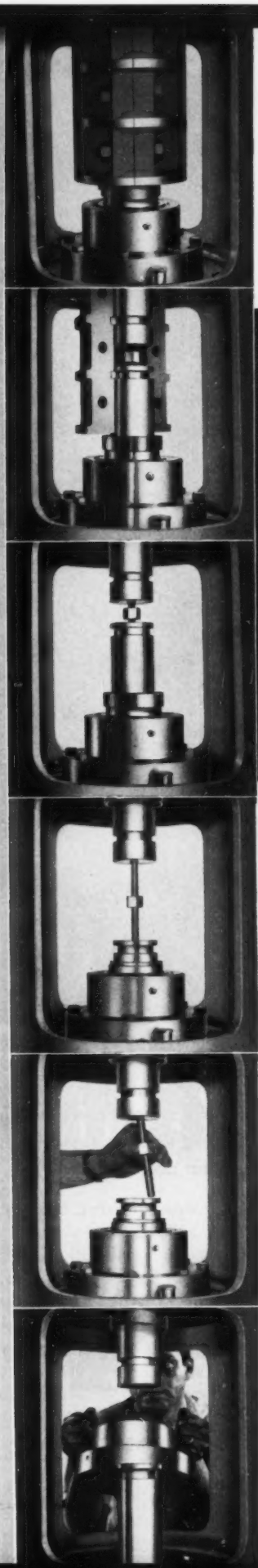
❶ Release sleeve collar set screws. Remove ½ of split sleeve coupling.

❷ Relieve shaft weight and remove remaining coupling half.

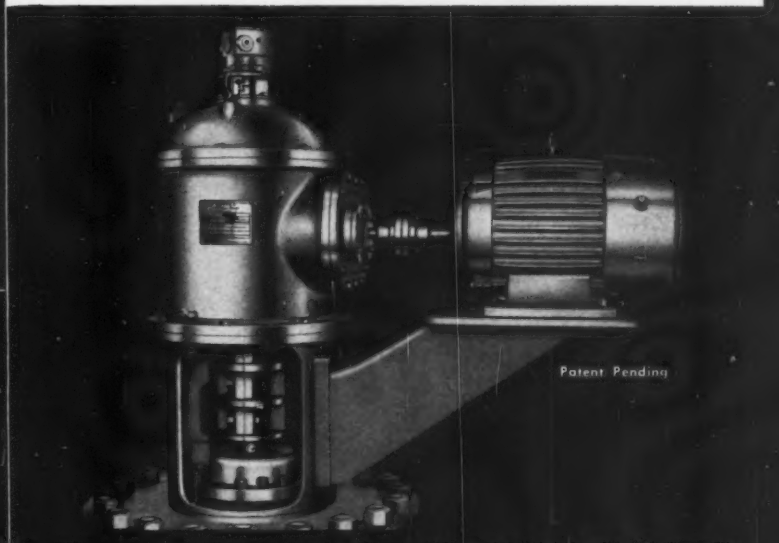
❸ Lower shaft on to support.

❹ Remove adjusting screw from opening.

❺ Unbolt and remove seal assembly. Reverse procedure to replace seal!



# *NEW!* EASIEST, QUICKEST MECHANICAL SEAL CHANGE CUTS MIXER MAINTENANCE COSTS!




Improved Processing Through Engineered Agitation

**A few turns of a wrench . . .** and Nettco seal assemblies on tank top mixers can be changed quickly, efficiently . . . regardless of mixer size. Costly downtime eliminated! Design simplicity reduces initial cost! No special skills or equipment required!

### DESIGN FEATURES

- No overhead lifting device required. Result: minimum overhead space needed . . . reduced maintenance labor and less downtime.
- Compact design with minimum distance between seals and drive bearings. Result: less shaft flexing at seals . . . reduced seal wear.
- Coupling jacks eliminated. Result: no working in cramped areas.
- No dismantling mixer . . . drive bearing untouched. Result: easier, faster seal maintenance . . . no bearing readjustment problems.

Nettco's Seal Replacement is easiest ever. For complete details, write for Bulletin 601 on your company letterhead. **Nettco Corporation, 81 Tileston St., Everett 49, Mass.**

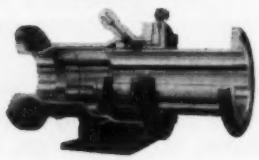
**NETTCO**

ENGINEERED AGITATION SPECIALISTS

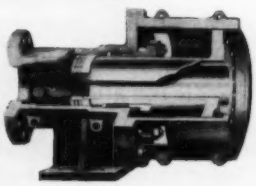
EVERETT 49, MASSACHUSETTS

ONLY ADSCO HAS ALL 3 TYPES OF EXPANSION JOINTS

CORRUFLEX PACKLESS



RAM-PAK



SLIP TYPE

... real peace of mind, the result of doing business with completely reliable Adsco. For more than 80 years, Adsco has carefully handled customers' expansion problems in their piping systems, from engineering through manufacture. Consult Adsco for your peace of mind.

Write for comprehensive catalogs

**ADSCO** ENGINEERED PRODUCTS

*Sold, Engineered and Manufactured by*

YUBA HEAT TRANSFER DIVISION

**HONESDALE, PA.**

*World's Oldest and Largest Manufacturer of Packed and Packless Expansion Joints*

YUBA

**YUBA CONSOLIDATED INDUSTRIES, INC.**

***YUBA — A growth corporation serving growth industries***

*chemical*
*petroleum*
*steam — electric*
*hydro — electric*
*aeronautics*
*construction*
*heating*
*air-conditioning*
*consumer durable*

*Practically Perfect!

# HUMBLE COREXIT

Save time and money previously lost to internal corrosion: use Humble COREXIT . . . COREXIT effectively and economically prevents internal corrosion in pipe still overhead, distillation towers, vapor recovery systems and other refining units. COREXIT will reduce or completely eliminate plugging or fouling. This protection against sludge, scale and corrosion cuts non-productive downtime to a minimum. For complete information on technical services and products, contact your Humble salesman.

HUMBLE

HUMBLE OIL & REFINING COMPANY



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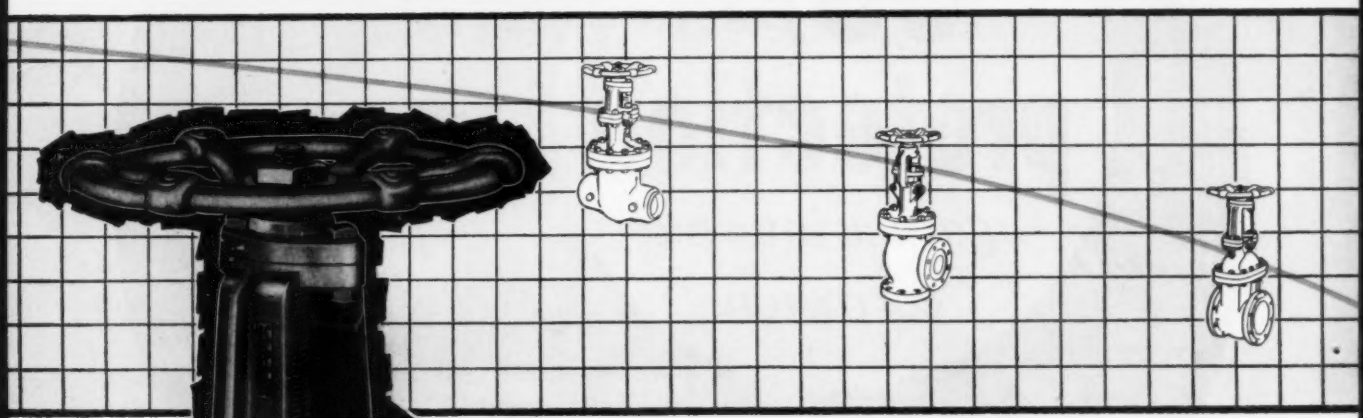
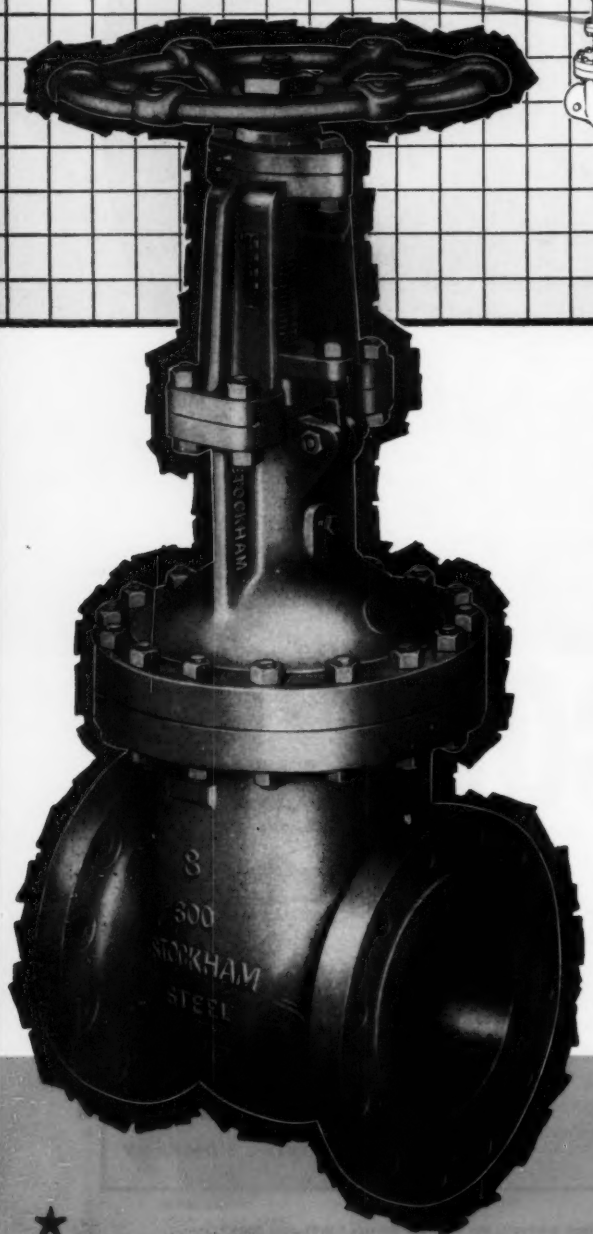
# Engineered to Cut Valve Maintenance Costs

## STOCKHAM STEEL GATE VALVES






GET THE design features you want and need to cut costs—get quality that lasts—in Stockham Steel Gate Valves.

Get full pipe size straight through port design. Seat rings are slotted; **no lugs protrude** in flow area.

These features make it the **easiest conventional type gate** valve to use in "pigging lines" and "hot tapping"—far more economical than conduit designs.

Other superior cost-cutting features include:

- ★ Disc and seat rings are precision ground for perfect seating
- ★ Disc guided throughout travel—eliminates wear
- ★ One piece yoke and cap—quick, easy maintenance
- ★ Non-corrosive copper nickel yoke bushing.

Precision quality control at every level of manufacture. Available in a wide variety of body and trim combinations. Gate, Globe, Angle and Swing Check Valves. 150, 300, and 600 Pound Pressure Classes.

CALL YOUR STOCKHAM DISTRIBUTOR OR WRITE

**STOCKHAM**
**VALVES *and* FITTINGS**

General Offices and Plant
4003 NORTH 10th AVENUE BIRMINGHAM 2, ALABAMA

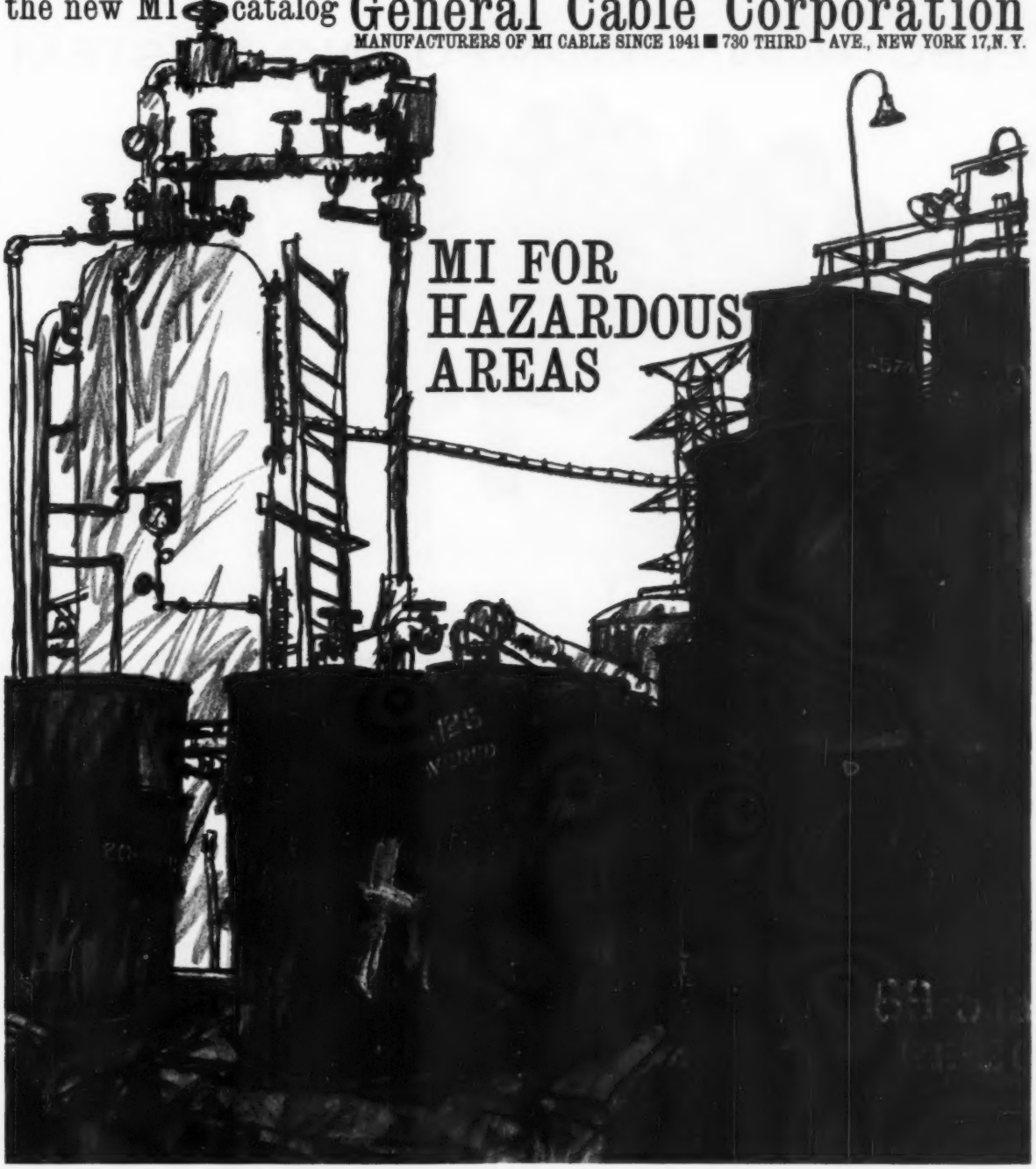
★ NON-LUBRICATED PLUG VALVES...
CAST IRON, MALLEABLE AND DUCTILE IRON PIPE FITTINGS
BRONZE, CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES

**SOLD ONLY THROUGH DISTRIBUTORS**

Oil companies throughout the country specify Safety MI Cable for hazardous applications and for remote control and instrumentation. Outstanding design engineers recommend it. One four-part reason... MI's exceptional record of safety, efficiency, permanence and economy. ■ Investigate the many unique characteristics of this versatile cable construction by writing for the new MI catalog

General Cable Corporation

MANUFACTURERS OF MI CABLE SINCE 1941 ■ 730 THIRD AVE., NEW YORK 17, N. Y.



BRONZE, CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES SOLD ONLY THROUGH DISTRIBUTORS

For engineering, for research, for business data processing in companies both large and small... **The new, fully-transistorized**

# RPC-4000

## ELECTRONIC COMPUTING SYSTEM

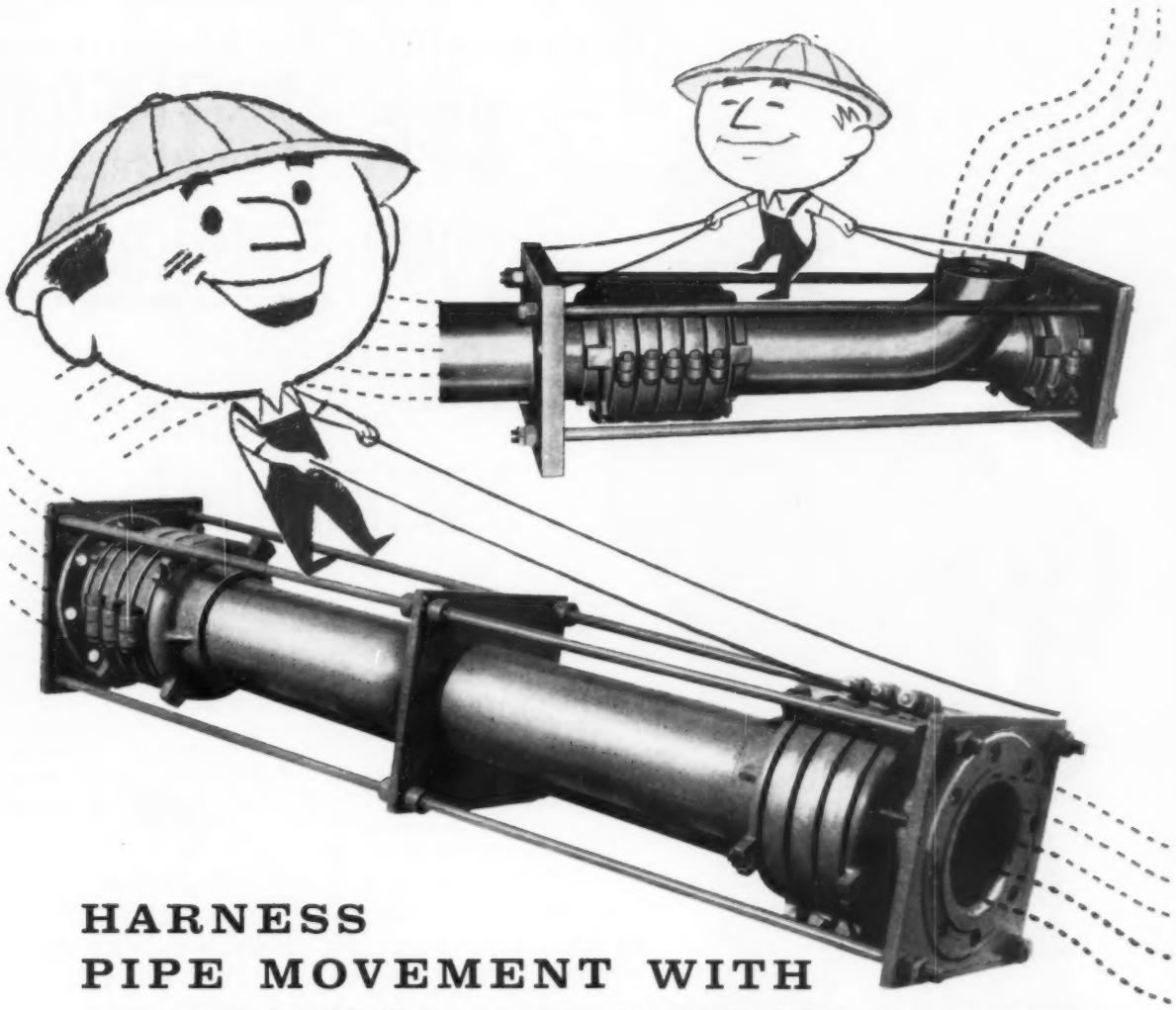
*another* outstanding computer value
... marketed by Royal McBee Corporation

**Advanced design:** fully transistorized—with important new computer design concepts that provide the largest memory, greatest problem-solving capacity and flexibility in the low- or medium-priced field. Entire system—computer, input-output typewriter and tape punch-read console—have been specially designed as a unit. **High-speed computing ability:** extra large capacity (8008 words) magnetic drum memory, with special fast access features. Computing speeds of up to 230,000 operations per minute. **Ultra high speed input-output:** 500 characters per second photoelectric punched paper tape reader, and 300 characters per second paper tape punch available as optional equipment. **Easy to use:** maximum results can be obtained by non-technical personnel. Users benefit from free training, continuing assistance, an extensive library of programs. Versatile command structure provides programming speed and flexibility. **Low in cost:** priced just above the small-scale computers, the RPC-4000 outperforms computers costing many times more. **Economical to install and operate:** no site preparation, air-conditioning or special maintenance required. Plugs into any standard wall outlet. **Multiple application ability:** designed to perform engineering, scientific and research calculations, as well as business data processing and management control functions.

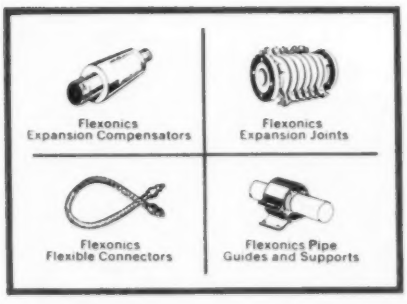
The RPC-4000 is a product of the Royal Precision Corporation, and is marketed by the Data Processing Division of Royal McBee. It is the latest member of the growing family of electronic computers from the people whose LGP-30 has become the world's leading small-scale computer.

**Royal Precision Corporation**

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. RPC-4000 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For full specifications, write **ROYAL McBEE CORPORATION,** data processing division, Port Chester, N.Y.



# HARNESS PIPE MOVEMENT WITH FLEXONICS EXPANSION JOINTS




Here's how to keep pipe movement under control! **Flexonics Self-Restrained Dual Expansion Joints** can absorb large amounts of lateral movement while keeping anchor forces at a minimum. **Flexonics Pressure Balanced Expansion Joints** replace main anchoring at changes in piping direction, by restraining the end thrust.

These are just two of the standard and special types of expansion joints engineered and built by Flexonics to help you harness pipe movement. **Check and mail the coupon today for complete information.**

EJMA Member Expansion Joint Manufacturers Association

EJ-260

**Flexonics** corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

EXPANSION JOINTS · METAL HOSE · SYNTHETIC HOSE · BELLOWS · AERO/SPACE COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY!

Flexonics Corporation
1336 South Third Avenue
Maywood, Illinois

Please rush me complete information on

- ☐ Expansion Joints
- ☐ Expansion Compensators
- ☐ Flexible Connectors
- ☐ Pipe Guides and Supports



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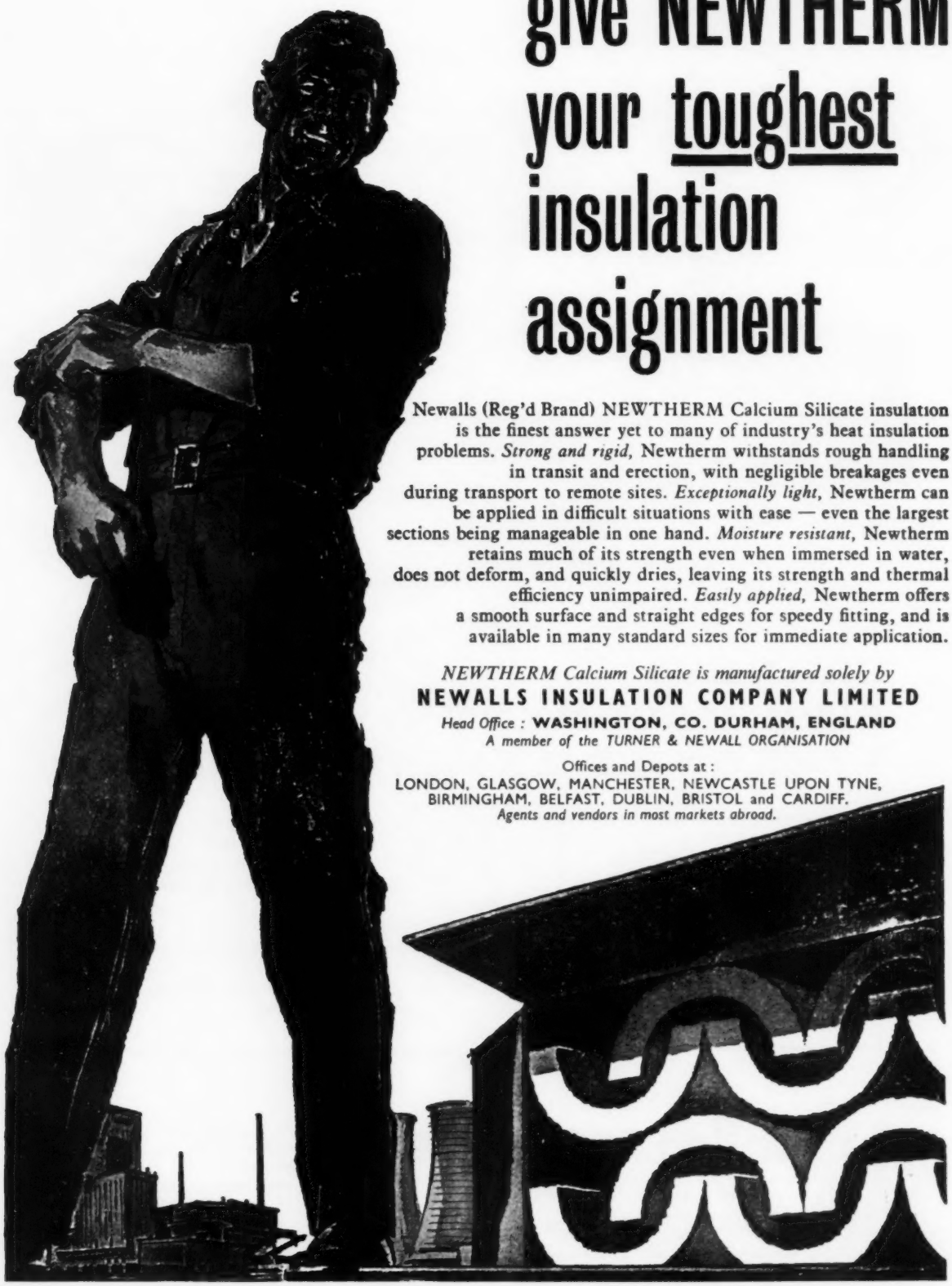

# give NEWTHERM your toughest insulation assignment

Newalls (Reg'd Brand) NEWTHERM Calcium Silicate insulation is the finest answer yet to many of industry's heat insulation problems. *Strong and rigid,* Newtherm withstands rough handling in transit and erection, with negligible breakages even during transport to remote sites. *Exceptionally light,* Newtherm can be applied in difficult situations with ease — even the largest sections being manageable in one hand. *Moisture resistant,* Newtherm retains much of its strength even when immersed in water, does not deform, and quickly dries, leaving its strength and thermal efficiency unimpaired. *Easily applied,* Newtherm offers a smooth surface and straight edges for speedy fitting, and is available in many standard sizes for immediate application.

*NEWTHERM Calcium Silicate is manufactured solely by*

**NEWALLS INSULATION COMPANY LIMITED**

*Head Office :* **WASHINGTON, CO. DURHAM, ENGLAND**

*A member of the TURNER & NEWALL ORGANISATION*

Offices and Depots at :
LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF.

*Agents and vendors in most markets abroad.*




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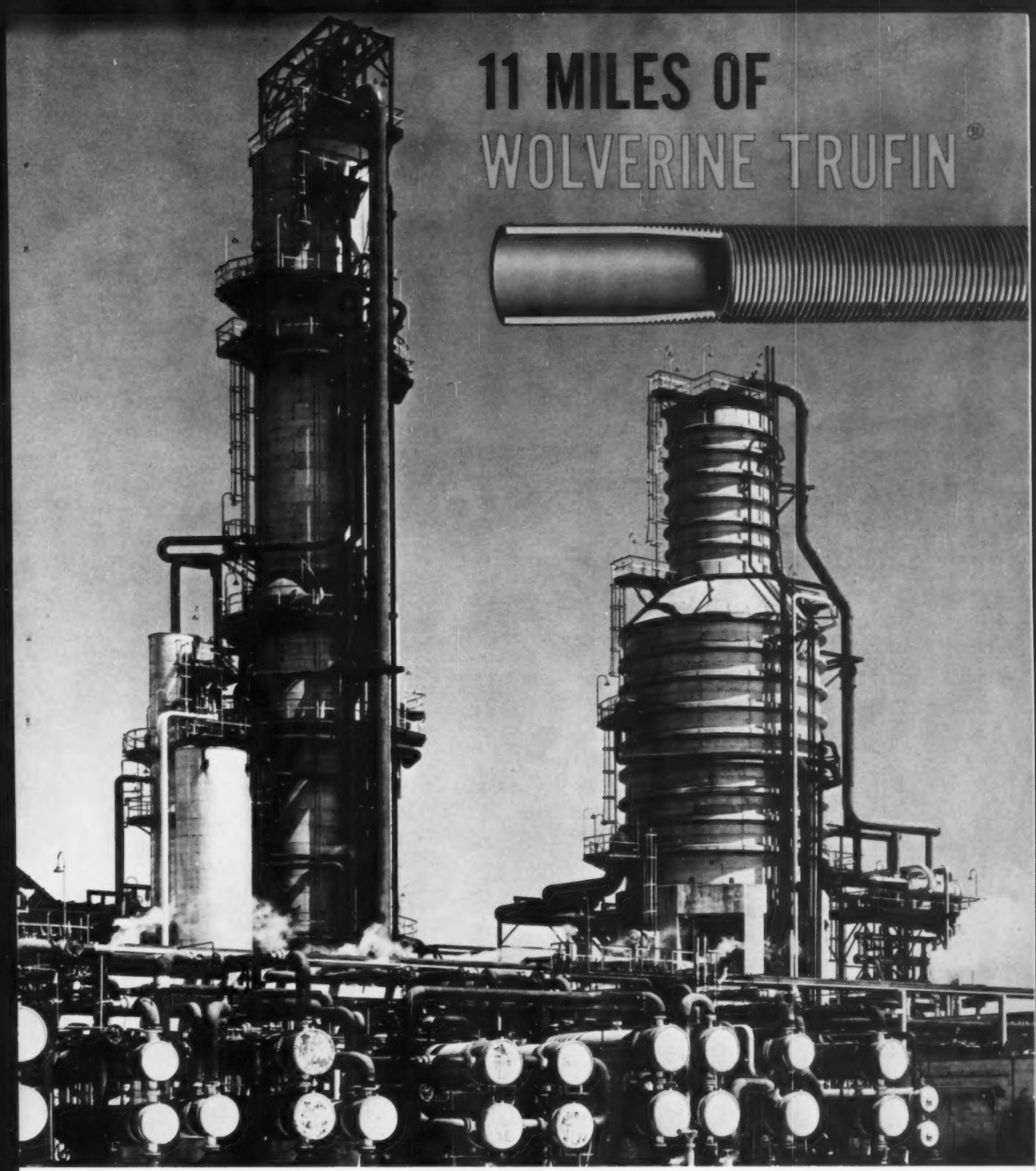



More than 11 miles of Trufin Type S/T–the integral finned tube–have been used in nine of the shell and tube heat exchangers which are the heart of the world's largest crude oil pipe still. Located in a midwestern refinery, the still is producing 140,000 barrels per day! More than 95% of the Trufin involved is made from Admiralty Brass.

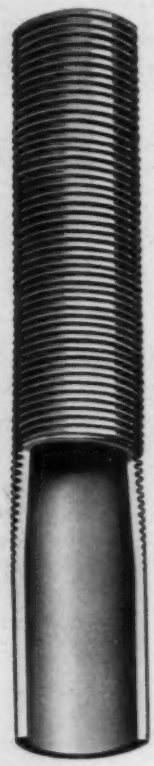
Yes, 11 miles of Trufin is a lot of tube–but just visualize the space savings that Trufin has provided. To perform the same heat duty as Trufin, more than 20 miles of prime surface tube would have had to be used. The advantages are obvious–fewer tubes, fewer shells, much less space required, and more production.

The complete range of finned tube products made by Wolverine Tube is shown on the other side of the page. It's a product line proven by experience.

Write today for more information.

# Wolverine Tube manufactures the industry's most complete line of finned tube

PRIME SURFACE TUBE

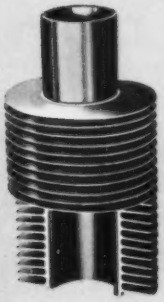


WOLVERINE TRUFIN TYPE S/T

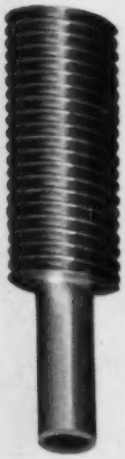
WOLVERINE TRUFIN TYPE W/H

DUPLEX PRIME SURFACE TUBE

DUPLEX WOLVERINE TRUFIN, TYPE S/T

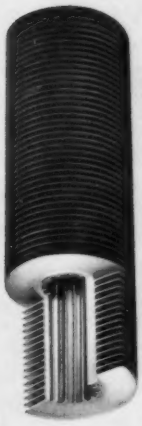


WOLVERINE TRUFIN TYPE L/C
Bimetal



WOLVERINE TRUFIN TYPE H/R

WOLVERINE TRUFIN TYPE H/A



WOLVERINE TRUFIN TYPE I/L

FINNED AND PRIME SURFACE U-BENDS
arranged in a disposable box-type pallet

## LET US TELL YOU ABOUT IT

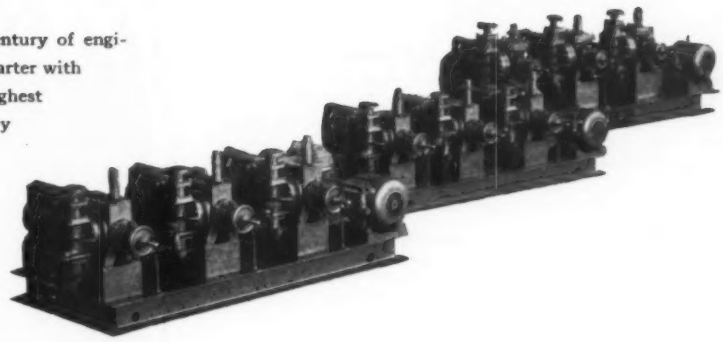
**WOLVERINE TUBE**
DIVISION OF
**Calumet & Hecla, Inc.**
DEPT. C, 17236 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality Controlled Tubing

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA • SALES OFFICES IN PRINCIPAL CITIES

# 25 YEARS OF SERVICE

## TO INDUSTRY

This year we celebrate a quarter of a century of engineering achievement and enter our 2nd quarter with the same determination to maintain the highest standards of skill and service to Industry with which we started 25 years ago.



E.C.D. LTD

**E.C.D. Ltd., Engineers, Tonbridge, Kent, England**

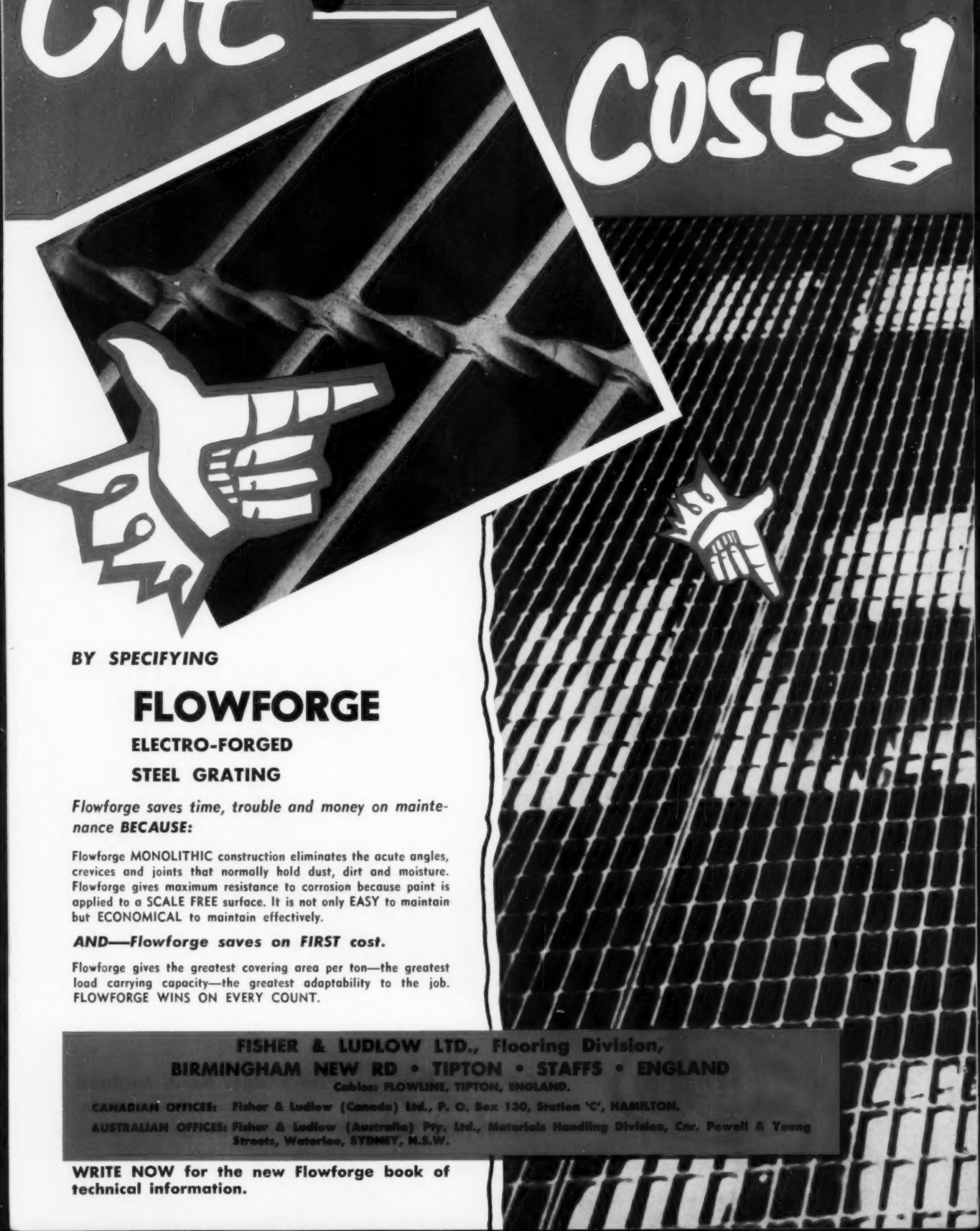
Telephone: Tonbridge 2237 (3 lines) Telegrams: TONMIL, TONBRIDGE.

One of the Wallace & Tiernan group of Companies.



For more data on advertised products, use Readers' Service Cards, last page.

# Cut your maintenance Costs!



*BY SPECIFYING*

## FLOWFORGE

**ELECTRO-FORGED**

**STEEL GRATING**

*Flowforge saves time, trouble and money on maintenance* ***BECAUSE:***

Flowforge MONOLITHIC construction eliminates the acute angles, crevices and joints that normally hold dust, dirt and moisture. Flowforge gives maximum resistance to corrosion because paint is applied to a SCALE FREE surface. It is not only EASY to maintain but ECONOMICAL to maintain effectively.

***AND—Flowforge saves on FIRST cost.***

Flowforge gives the greatest covering area per ton—the greatest load carrying capacity—the greatest adaptability to the job. FLOWFORGE WINS ON EVERY COUNT.

**FISHER & LUDLOW LTD., Flooring Division,**
**BIRMINGHAM NEW RD • TIPTON • STAFFS • ENGLAND**
Cables: FLOWLINE, TIPTON, ENGLAND.

CANADIAN OFFICES: Fisher & Ludlow (Canada) Ltd., P. O. Box 130, Station 'C', HAMILTON.

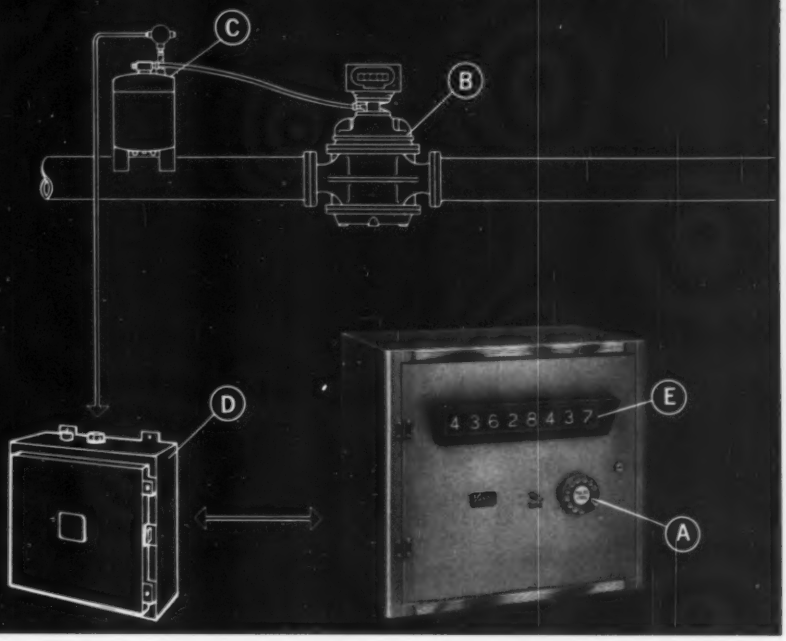
AUSTRALIAN OFFICES: Fisher & Ludlow (Australia) Pty. Ltd., Materials Handling Division, Cnr. Powell & Young Streets, Waterloo, SYDNEY, N.S.W.

**WRITE NOW for the new Flowforge book of technical information.**

# VAREC PULSE CODE

## A NEW ECONOMICAL AND RELIABLE SYSTEM FOR REMOTE READING OF P. D. METERS IN PETROLEUM PIPELINES

A Varec telemetering cycle takes just 7 seconds . . . starts when the operator uses a dial **(A)** to contact a selection point. The P. D. meter **(B)** responds, through mechanical coupling or electrical inpulse, through a transmitter **(C)** which transmits the data to a remote selector **(D)**. The selector provides for multipoint selection from widely scattered points . . . sends the data to the receiver **(E)** where it is decoded and displayed in digital form.




Varec's pulse code system, used with P. D. Meters, provides highly accurate, centralized telemetering across any distance . . . offers important user economy with a simple communications link of either a two-way physical line or carrier-derived channel.

The Pulse Code is a true digital system . . . transmits data rapidly in dots and dashes . . . provides 'error-proof' reading even while the P. D. Meter is running.

Typical Varec system features include: the code is established by Varec transmitters which are available in models for either electrical or mechanical input . . . selectors with 10 to 100 selection capacities . . . high capacity receivers with 99 identification numbers and 6 digits of data (up to one million counts . . . and illuminated, "in-line" display receiver readings.

### VAREC PULSE CODE EQUIPMENT OFFERS ALL THESE ADVANTAGES

**ACCURACY:** Provides one point in one million accuracy for a six digit unit.

**RELIABILITY:** Consists of simple, compact electro-mechanical components . . . needs no vacuum tubes or other complex electronic equipment.

**FLEXIBILITY:** Designed on a building block principle that permits unlimited variety of system arrangements for telemetering measurements of any transducers with an electrical or mechanical output . . . or adding remote control, data logging and alarm systems.

**ECONOMY:** Requires much lower wire count . . . only a single communications channel—between receiver and gauging point.

**EXPERIENCE:** Offered by Varec . . . pioneers in the remote gauging field with over six years field experience in liquid level and temperature telemetering.

For more information on the Varec Pulse Code/P. D. Meter System, write for Varec Bulletin CP-3701, Dept. PR-1223-1.

"Varec"
TRADE ® MARK

THE VAPOR RECOVERY SYSTEMS COMPANY
2820 North Alameda Street • Compton, California
*Branches and Representatives in Principal Cities*



For more data on advertised products, use Readers' Service Cards, last page.

# Refinery

# Maintenance Made Simple

Here are the quality leaders, the names in refining, natural gasoline and petrochem plant equipment synonymous with performance.

When you specify pipe, valves or welding fittings made by these manufacturers, you know you are getting quality. You know that longer service life and less down time result when quality equipment is installed. We are proud to offer you these quality leaders. We know that the research and development invested in these products mean more satisfied customers for J&L.

You can have up-to-date literature on any of these products by calling your local J&L man.

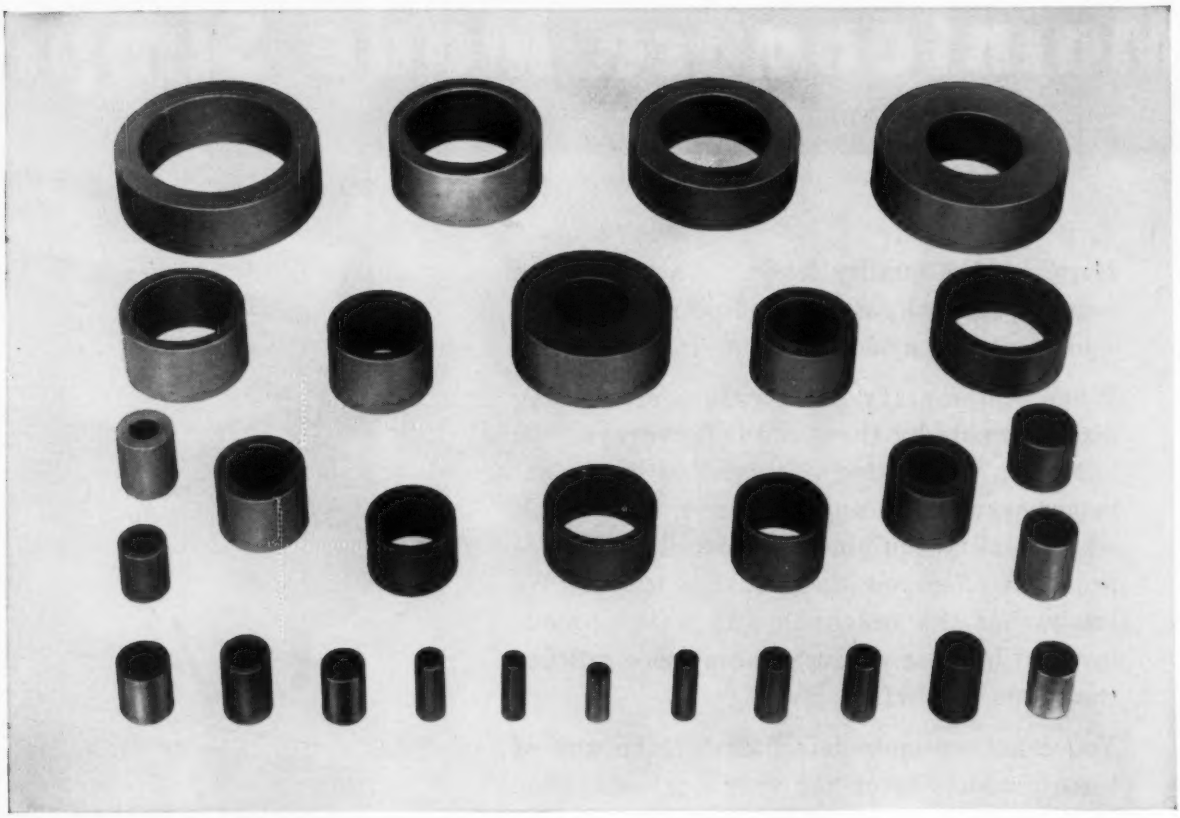
Specify quality.... and save at J&L.

**Jones & Laughlin**

**SUPPLY DIVISION – Tulsa**

If it's sold by J&L....
It's the best available

108



# 2 ways to save on pressure tubing

**1. GET TIMKEN QUALITY STEEL**

When you get Timken® steel pressure tubing, you get the finest quality tubing your money can buy. Quality that assures long, economical service. And it begins in the Timken Company mill with fine alloy steel, melted in the most modern electric furnaces in this country. Experts in melting, piercing, finishing, and inspection guard this quality for you using many procedures that are virtually unique in the steel industry. For example, *all* tubes are specially conditioned to assure finer finish. And backing all this technical ability are *30* years of experience in producing pressure tubing. The result is quality that assures you *the longest tube life per dollar.*

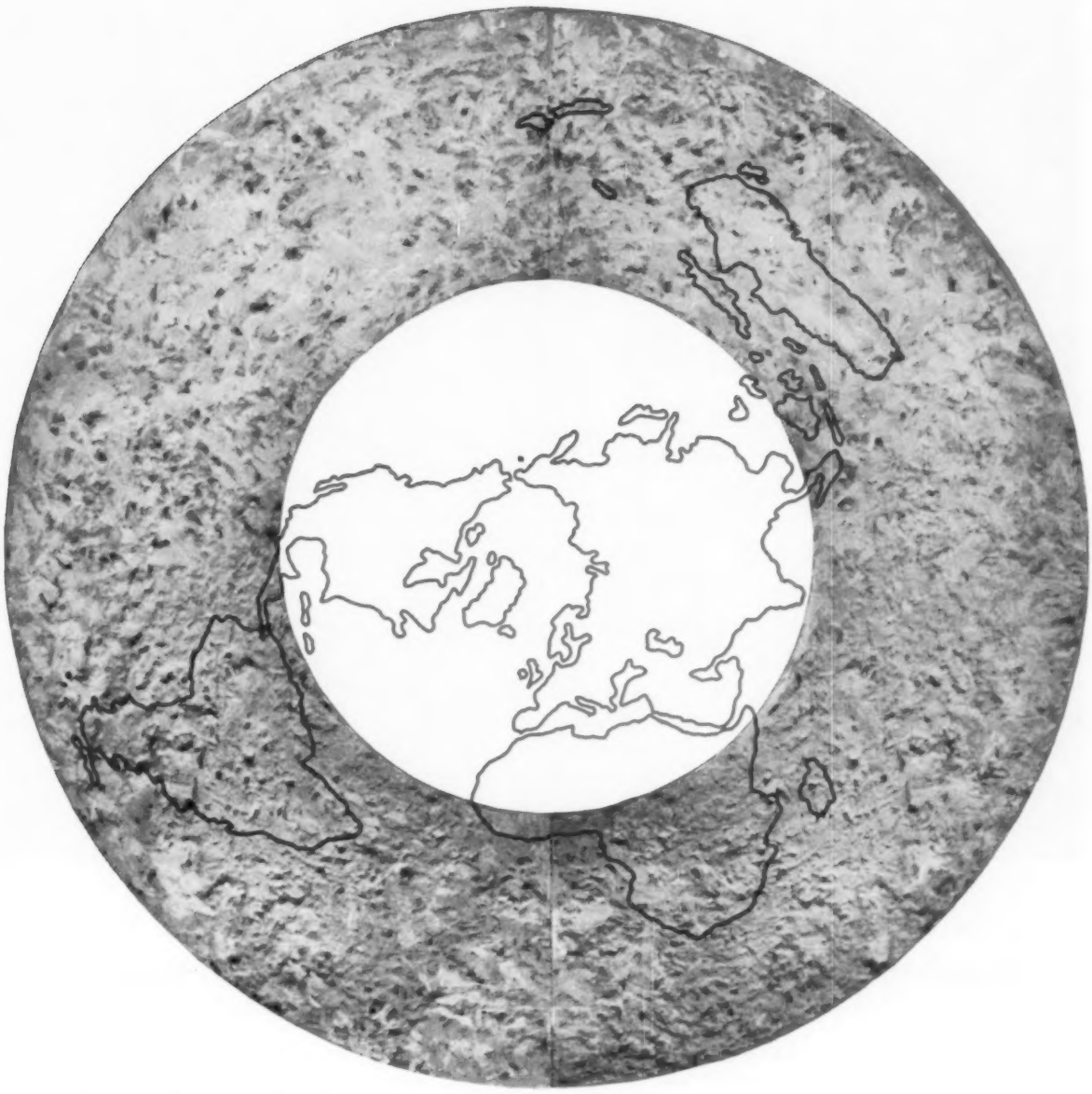
**2. LET TIMKEN COMPANY EXPERTS HELP SOLVE YOUR PRESSURE TUBE PROBLEMS**

Whatever your steel pressure tube problems—corrosion, oxidation, heat, pressure—Timken Company steel experts can help solve them. They've solved hundreds of the toughest problems in every field, from steam generators to chemical plants. From the wide range of diameters and wall thicknesses available in Timken pressure tubing, (typical examples shown above) we can select the most economical size in the right analysis for your needs.

Get quality pressure tubing that will save you money. Specify Timken steel pressure tubing. ***When you buy Timken steel you get . . .*** *1) Quality that's uniform from heat to heat, bar to bar, order to order. 2) Service from the experts in specialty steels. 3) Over 40 years experience in solving tough steel problems.* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.*

# TIMKEN® *Fine Alloy* STEEL

**TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES**



# made the world over

—and to the same specification

Caposite amosite asbestos is manufactured under supervision to the same uniform specification in all these countries.

| | |
|---|---|
| Great Britain | by The Cape Asbestos Company Ltd |
| Canada | by Caposite Insulations Ltd |
| South Africa | by Cape Asbestos Insulations (Pty) Ltd |
| Australia | by James Hardie & Company Ltd |
| France (as 'Isolamiante') | by Isolamiante SA |
| Italy | by Capamianto SpA |
| Holland | by J. de Boer & Company |
| Spain | by Messrs. Eduardo Rosa |
| Argentina | by Montisol Argentina. SRL |
| Japan | by Nippon Asbestos Company |

Amosite asbestos insulation is also manufactured in U.S.A. under the name of 'Unibestos' by Union Asbestos Rubber Company.

**CAPOSITE** regd.

**AMOSITE ASBESTOS INSULATION**

CAPE

THE **Cape Asbestos** COMPANY LTD 114 & 116 Park St. London W1. Grosvenor 6022

Enquiries to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario. North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois. Capamianto SpA via Sant' Antonino 57, Turin, Italy.

TA.3612



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Utah Oil Company's story tells why...

## Modern Refineries Are Choosing B&W CO® Boilers

In May, 1958, a Babcock & Wilcox CO Boiler went on stream at Utah Oil Company's Salt Lake City refinery. Results: 1) Fuel-oil consumption has been about 55 to 60% of that needed for conventional boilers. 2) Incremental payout of the CO Boiler over that of conventional equipment is about 2.2 years, after taxes. Fuel-oil saving alone is enough to pay out the entire investment in 6.2 years, after taxes. 3) Maintenance costs are equal to or less than those for conventional equipment. Both water-side and fire-side tubes were clean after 24 months' operation. 4) The CO Boiler is operated as part of the cat cracking unit, with no increase in personnel.

The unit can generate 138,000 lb of steam per hour at 300 psig and 540 F. The boiler can operate on oil plus combustibles in the cat cracker regenerator flue gas, or on oil alone.

The CO Boiler was installed to take care of increasing steam requirements. The sensible heat of the waste regenerator gases was already removed with an existing waste heat boiler. Selection of a CO Boiler over conventional steam-generating equipment was made to utilize the waste combustible heat from the 17,500 bbl/D fluid unit, and to utilize existing manpower.

CO Boilers are setting similar performance and economy records in refineries throughout the world. The B&W CO Boiler is the only unit specifically designed for efficient burning of "waste" carbon monoxide. Check your own steam costs—then check with us and learn how a CO Boiler can cut those costs. The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

CO-107

B&W THE BABCOCK & WILCOX COMPANY

BOILER DIVISION



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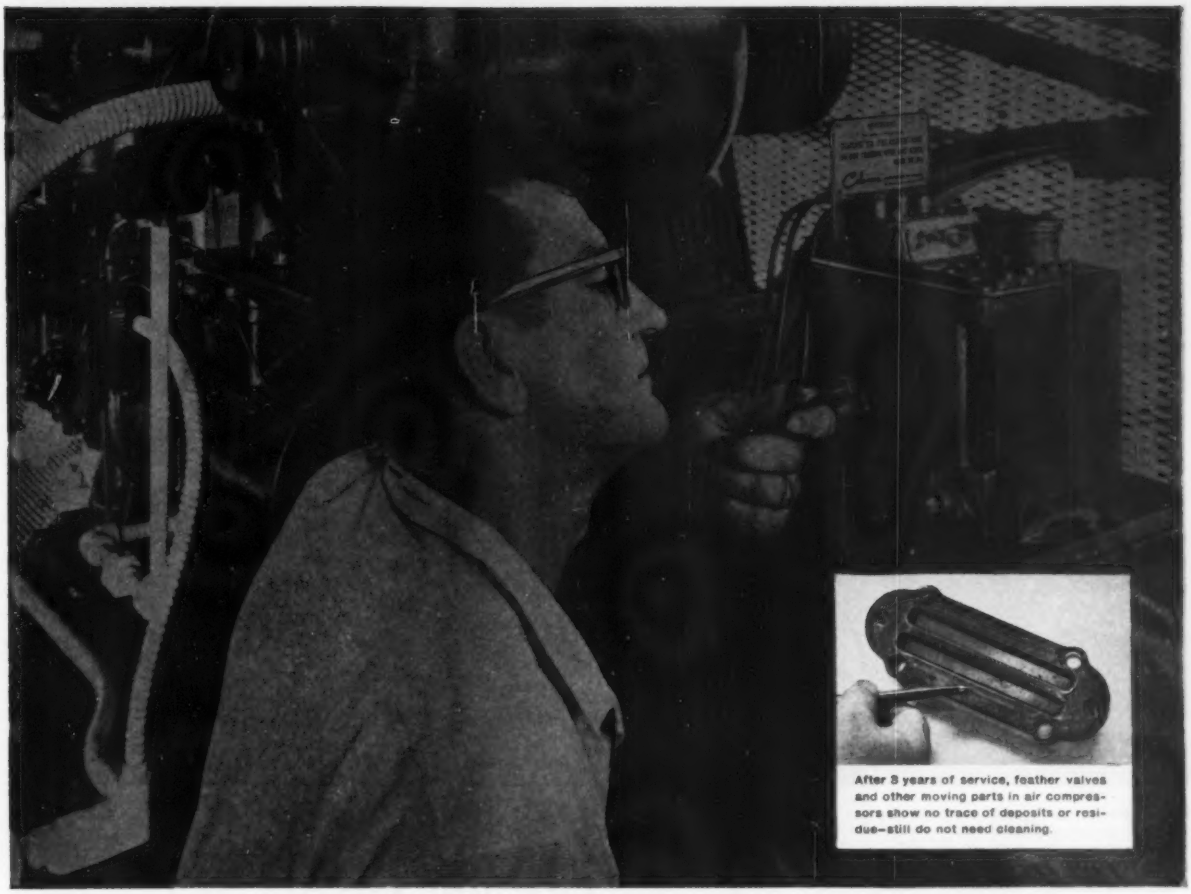


After 8 years of service, feather valves and other moving parts in air compressors show no trace of deposits or residue—still do not need cleaning.

# "Cellulubes eliminate fires and explosions ... keep compressor parts clean"

**says MR. T. E. DANIEL, Foreman, Cypress Compressor Station**
**Trunkline Gas Company, Cypress, Texas**

"Since using Cellulube 220 in our air compressors we have never experienced or had any indication of fire or explosion in our compressed air systems," continues Mr. Daniel.

Installed at Trunkline's Cypress Compressor Station when it opened three years ago, Cellulubes thus provide an authoritative 7800-hour operating record that indicates not only efficient and far safer operation, but substantial savings as well. Mr. R. C. Carter, Trunkline's Compressor Department Superintendent, describes them thus:

"First and most important, of course, is the elimination of any risk to our personnel—from fire, explosion, or fragmentation. Secondly, we save on heavy equipment replacement costs, and thirdly, down-time losses.

"A major savings is in preventive maintenance. Formerly, we completely disassembled and cleaned air compressors every six months. Cellulubes keep machinery so clean that this interval has been indefinitely extended, and so far we've saved at least 60 man-hours. Finally, Cellulubes never get 'dirty,' nor do they burn away by friction or compression."

Cellulubes . . . the *safe* lubricants and hydraulic fluids . . . are available in six controlled viscosities. If you'd like a sample for evaluation, please let us know the application involved.

Celanese Chemical Company, a Division of Celanese Corporation of America, Dept. 574-G, 180 Madison Avenue, New York 16, N. Y.

Celanese® Cellulube®

**Cellulubes... Celanese CHEMICALS fire-resistant functional fluids**

Canadian Affiliate: Canadian Chemical Co., Limited, Montreal, Toronto and Vancouver • Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, New York 16, N.Y.

# THE YARWAY FAMILY OF FINE STEAM TRAPS

**SERIES 60**—normal needs, pressures to 400 psi, 6 sizes. **SERIES 120**—normal needs, pressures to 600 psi, 6 sizes. **SERIES 40**—for extra heavy loads, 5 sizes. **NO. 30**—for extra light loads (½" only). **INTEGRAL STRAINER**—highest pressures and marine use, 6 sizes.

## NEW NO. 30 IS A LIGHT LOAD SPECIALIST

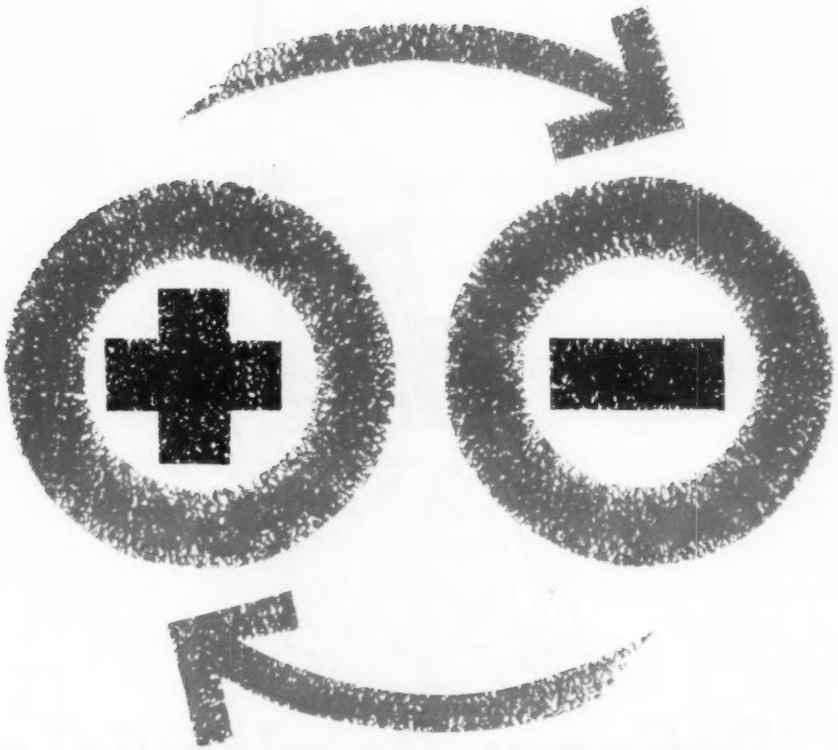
When the condensate load in your steam lines is *extra light*—this new Yarway ½" No. 30 Steam Trap is *exactly right.*

Specify it. You'll experience new *economy of operation* with the *tighter shut-off.* Operation is *quieter* due to lever action. *Maintenance is less*—because of the replaceable valve-seat assembly, only one moving part and stainless steel construction. Enjoy these special features plus all the regular advantages of famous Yarway Impulse Traps such as *quick heating, even temperatures, small size, good for all pressures, non-freezing.*

Over 1,250,000 Yarway Impulse Traps already sold; buy yours from one of 270 local Industrial Distributors.

**YARNALL-WARING COMPANY**
100 Mermaid Ave., Philadelphia 18, Pa.

**YARWAY** *impulse® steam traps*



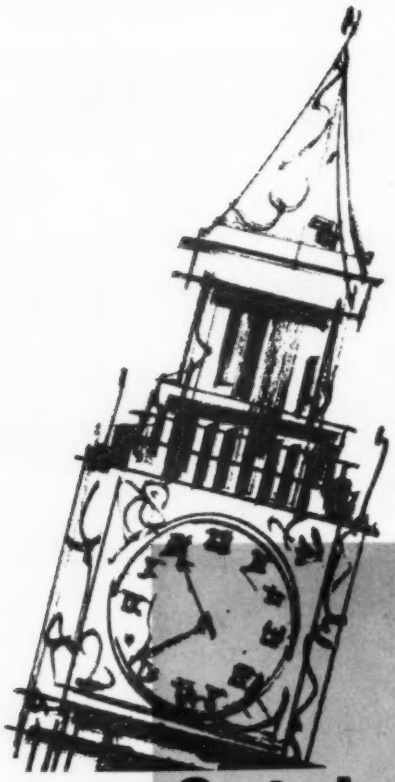
# An assignment in migrating ions... for Lukens Application Research.

Corrosion. This is the metallurgical result of ion migration. It's a frequent opponent for the Lukens Application Engineer in his job of helping you determine the *best* steel for "problem" applications. In the case of miscellaneous-cargo tankers, for instance, corrosive hot caustics are often carried on one leg of a trip; on another... high purity glycerine that must not become contaminated. How, marine designers asked, can we get *economical* protection both for cargoes and hold tanks? Drawing on years of experience with process industries equipment, Lukens Application Research suggested the answer: nickel-clad steel—highly corrosion-resistant, comparatively inexpensive—with a special sodium hydride finish that is easy to clean, expedites conversion.

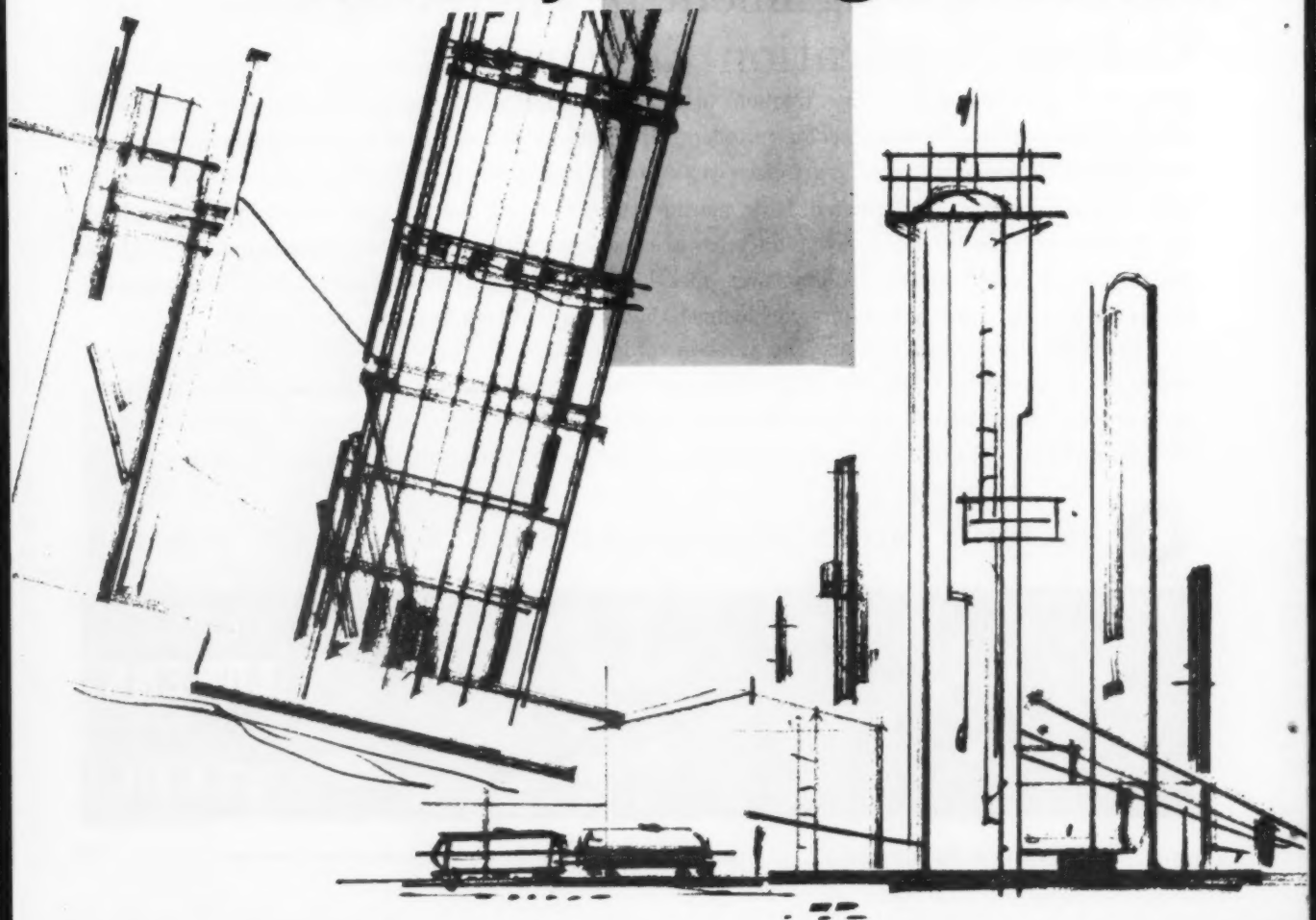
Experience and ingenuity are the stock-in-trade of Lukens Application Engineers. For personal assistance on problems of metals application—corrosion, cryogenics, metal expansivity, abrasion, structural stress—please contact us. Write Manager, Application Engineering, S-70 Services Building, Lukens Steel Company, Coatesville, Pennsylvania. Also contact us for Clad Steel Equipment Bulletin No. S-70.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

For more data on advertised products, use Readers' Service Cards, last page.



# Refinery Catalog is awake .



Like the refining and petrochemical industry, REFINERY CATALOG never shuts down. Through this exclusive industry buying handbook, more than 300 manufacturers and service companies maintain representatives at your side 24 hours a day, throughout the year.

In REFINERY CATALOG, you have – as near as your desk – complete or condensed catalogs describing in detail thousands of products and services used by the oil, gas and petrochemical processing industry.

# . . . . . 8,760 hours a year!

Completely cross-indexed for maximum efficiency, the REFINERY CATALOG makes buying or specifying as rapid and efficient as possible.

Take advantage of your perpetual corps of sales reps, REFINERY CATALOG. It's the buying data-reference book of the industry . . . the only one of its kind available.

Included in the 1960 REFINERY CATALOG is a *new feature*—the 128-page A·S·A Refinery Piping Code

**REFINERY CATALOG**

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*World's Largest Specialized Publisher to the Oil Industries*

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# DO YOUR OWN DELEGATING!

Segregate the critical piping. For lasting satisfaction and safety, trust your next job of prefabricating and installing high-pressure, high-temperature piping only to experienced specialists. Ask us for our "Brochure" of shop and field facilities, and also . . . ask us in.

**W. K. MITCHELL & CO., INC.**

**Philadelphia 46, Pa.**

*WESTPORT JOINT*
(PATENTED)

# *MITCHELL PIPING*
SINCE 1899

**PIPING FABRICATORS AND CONTRACTORS**



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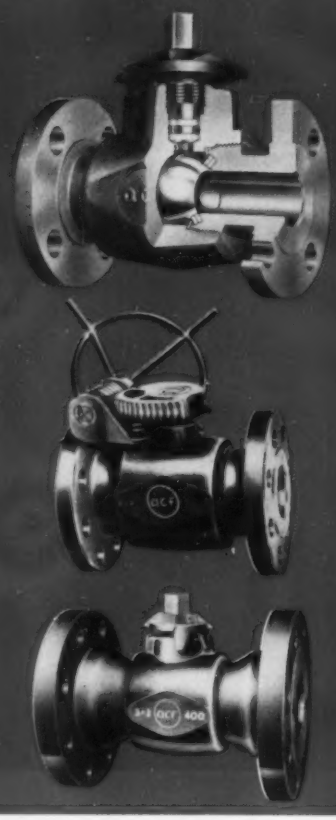
# "Install 'em anywhere – no maintenance needed"

PRODUCT OF W-K-M's

*Creative Engineering*



**ACF non-lubricated Ball Valves** feature Teflon stem gaskets and seats. There's no lubricant to cause sticking or contamination.

**Working Pressures:** In carbon steel with ASA ratings of 150 pound and 300 pound, and some sizes in ASA 600 pound; in semi-steel with 200 and 400 pound WOG ratings.

**Sizes:** ½" through 6". Regular port valves up to 8" x 6".

5922

## acf® non-lubricated Ball Valves

ACF Ball Valves are not only non-lubricated . . . but designed *throughout* for maintenance-free performance. For example: The ball is suspended between Teflon* seats under compression for leakproof sealing. Seats are protected from the lading flow. And the full bore conduit provides *smooth* flow, with no destructive turbulence . . . no more pressure drop than through an equal length of pipe.

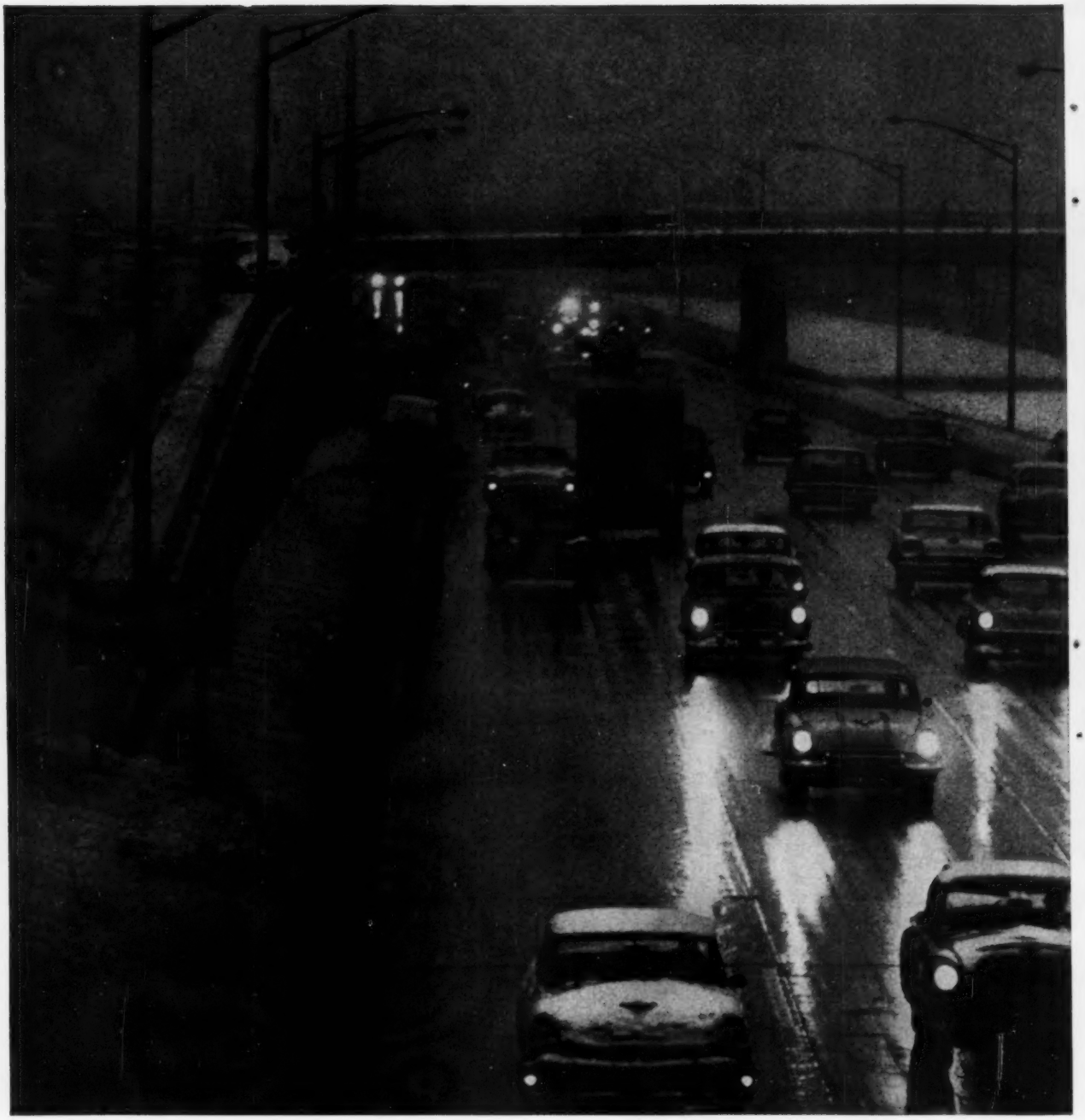
A quick quarter-turn operates this rugged valve. Specify it. You'll get efficient, economical performance. *Available from leading suppliers everywhere.*

* Du Pont Trademark

**WRITE FOR CATALOG 1000**

**W-K-M**

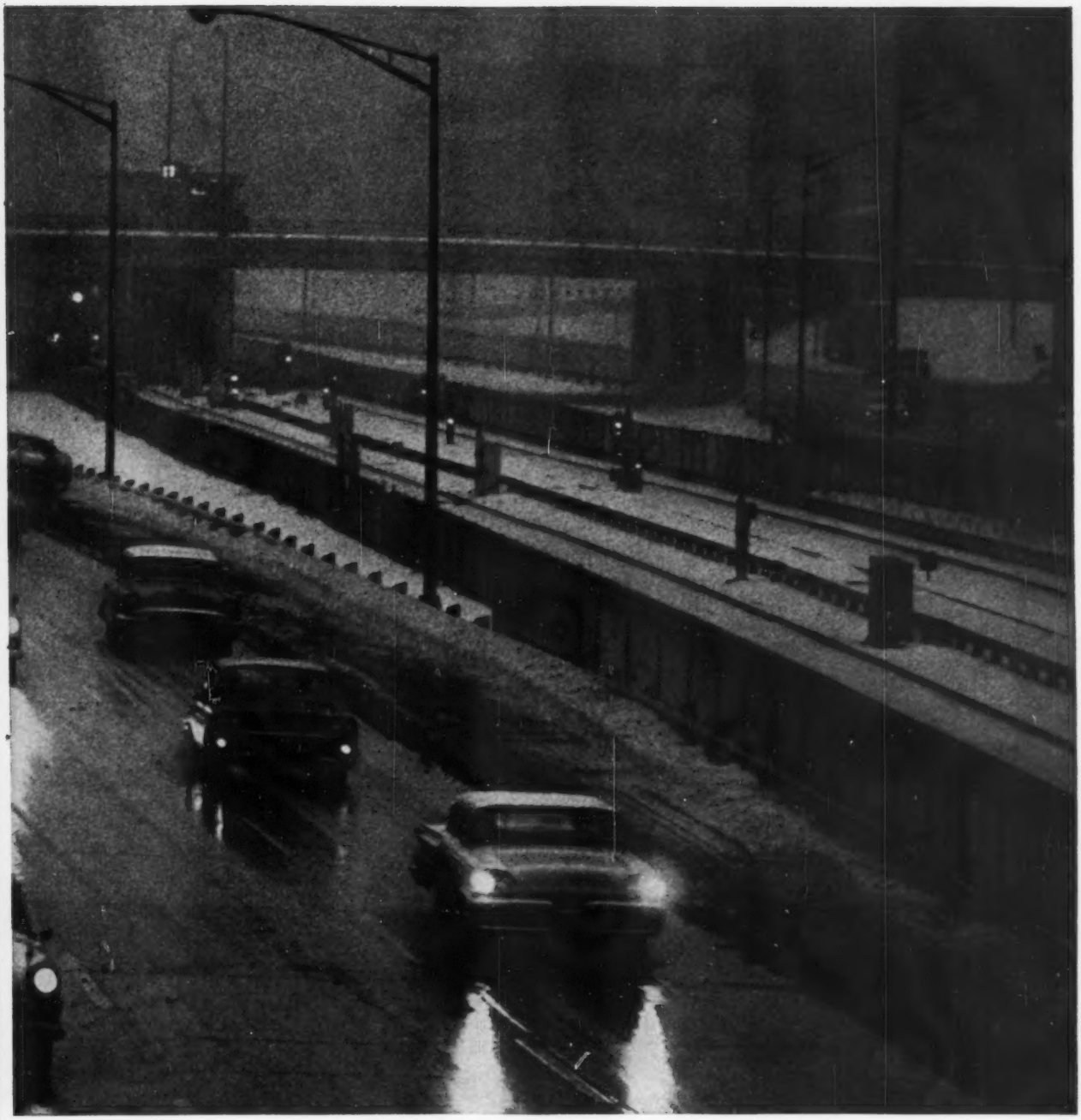
DIVISION OF acf INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS



# ARMOUR ANTI-STALLING ADDITIVES

Armour's **Duomeen®** compounds have been used successfully by major oil refiners the past several years to prevent carburetor icing. These anti-stalling additives are so effective that they are used on a ppm basis . . . amounts so small your costs are reduced to a fraction of what you pay for protection gained by the use of freezing-point depressants.

In addition to their anti-stalling properties, Armour's additives also help prevent corrosion and keep air-borne contaminants from forming on carburetor walls and parts. To reconfirm their savings and effectiveness in operation, an independent laboratory runs continuing tests on these Armour additives. Test results consistently establish the superior prop-



# KEEP 'EM ROLLING AT LESS COST

erties and economies of these Armour additives over freezing-point depressants.

*Armour also makes a wide variety of chemicals as specialized additives for automotive uses.* These polar nitrogen compounds have a broad range of use. In addition to preventing corrosion in greases, lube oils and gasolines, these compounds also improve lubricity in lubricating oils, transmission fluids and greases.

To learn more about Armour's gasoline anti-stalling additives and other refined product additives, and to receive samples of them, write to:

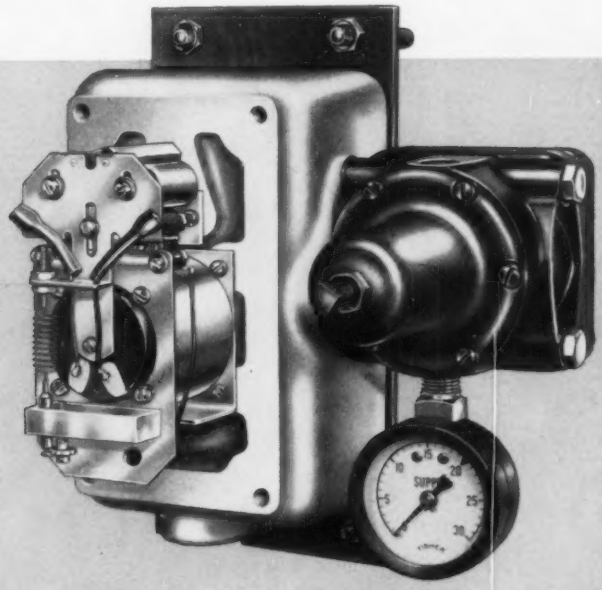
**ARMOUR INDUSTRIAL CHEMICAL COMPANY**
DIVISION OF ARMOUR AND COMPANY
110 North Wacker Drive, Chicago 6, Illinois



For more data on advertised products, use Readers' Service Cards, last page.

## Ask Your *FISHER/MAN* How To

# SPEED THE INPUT SIGNAL to the CONTROL VALVE



# FISHER

## TYPE 543

## ELECTRO PNEUMATIC TRANSDUCER

## Available with or without a pneumatic valve positioner

Here's an electro-pneumatic transducer developed for use in electrical control loops where the final control element is pneumatically operated. Explosion proof design makes it ideal for use under hazardous conditions. Input signals may range from 1 to 5 ma. through 10 to 50 ma. . . . output from 3 to 15 psi through 6 to 30 psi. Built-in volume relay permits direct operation of the pneumatic actuator from the Transducer. No extra relays or boosters needed. Relay can be serviced independent of electrical assembly. Unit is completely reversible by reversing input leads and rezeroing.

If you want additional information on the Type 543 Electro-Pneumatic Transducer write Fisher Governor Company.

| TYPICAL CIRCUITS | | |
|---|---|---|
| Input Current | Load Requirements of Controller | Actual Internal Resistance of Transducer |
| 1 to 5 ma dc | 3,000 ohms maximum | 2,500 ohms ±125 ohms |
| 1 to 5 ma dc | 12,000 ohms ± .5% | 12,000 ohms ± 50 ohms |
| 10 to 50 ma dc | 500 ohms maximum | 57 ohms ± 4 ohms |

| PERFORMANCE DATA | |
|---|---|
| Linearity | 1% of full range |
| Air Consumption Rate | 2 SCFH with 15 psi output pressure |
| Resolution Sensitivity | .05% of input range |
| Frequency Response | Complete frequency response data with Fisher topworks available |

TYPE 3541

Electro Pneumatic Controller Mounted on Control Valve

TYPE 543

Transducer Mounted on Control Valve

TYPE 543

Transducer Mounted on Stand Pipe

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

## FISHER GOVERNOR COMPANY

*Marshalltown, Iowa / Woodstock, Ontario / London, England*

CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

FISHER® Controls

*SINCE 1880*



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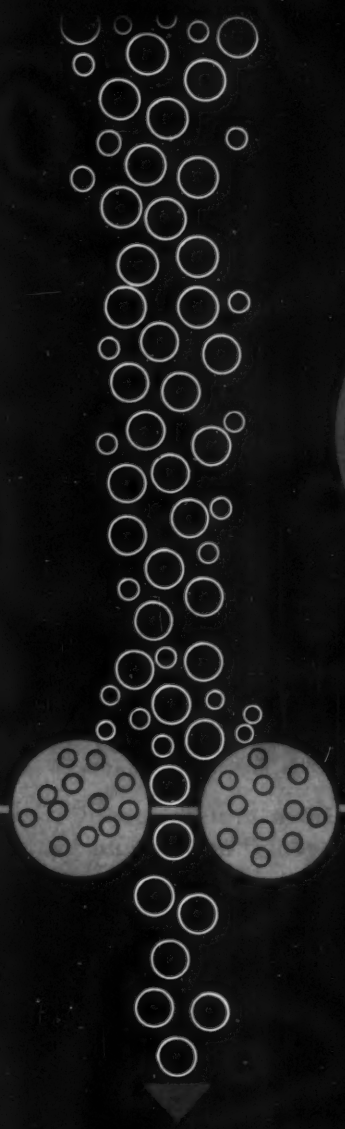

# NOW—DRY NATURAL GAS MORE ECONOMICALLY

## ...WHEN YOU ADSORB WITH LINDE MOLECULAR SIEVES

This is only one of many applications which utilize the high capacity and selectivity of LINDE Molecular Sieves. In fact, Molecular Sieves not only outperform other adsorbents, but do other adsorption jobs never before accomplished. Whether in new installations or as replacement adsorbent in existing units, Molecular Sieves can help you minimize both investment and operating costs. More specifically, here's how they are used. . .

**A major petrochemical** company has reduced the $CO_2$ content of its ethylene from 3000 PPM to less than 1PPM. This high purity is achieved in a single-stage process, automatic and non-corrosive, which has proved to be more economical than the alternative four-stage process. Other petrochemical uses include drying of cracked gases, ethylene, hydrogen, liquid propylene, solvents and many other gases and liquids. **Natural gas producers** use Molecular Sieves for drying and sweetening of natural gas, for sweetening of liquid propane and butane, and for drying of adsorber oil. **Petroleum refiners** use them to gain efficiency in drying reformer hydrogen, liquid butane LPG and transformer oil, and for removal of impurities such as $CO_2$ and mercaptans **Refrigeration manufacturers** use Molecular Sieves as a desiccant in super-drying refrigerants to eliminate freeze-up and corrosion.

For these and many other adsorbent applications, you can rely on patented LINDE Molecular Sieves to perform more effectively. They are the top quality material of their kind available today, always uniform, with high capacity, high strength, and high bulk density. They are available in regular and special grades to meet your specifications.

LINDE technical know-how—gained from years of laboratory and field work with adsorption problems—can help make Molecular Sieves work profitably for you. For further information, write: Dept. PR-07 Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. **In Canada:** Linde Company, Division of Union Carbide Canada Limited, Toronto 7, Canada.

### SOME AREAS WHERE MOLECULAR SIEVES IMPROVE ADSORPTION

- Purification of ethylene
- Drying gases, liquids, solvents
- Drying, sweetening natural gas
- Sweetening liquid propane, butane
- Drying jet fuels
- Octane improvement
- As refrigerant desiccant
- Controlled atmosphere purification

## LINDE COMPANY

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UNION CARBIDE

HELPFUL WATER CONDITIONING DATA FROM BETZ

# POLYELECTROLYTES . . . NEW

**New coagulants and coagulant aids have brought about improvements that verge on the spectacular and should be investigated wherever coagulation is practiced.**

INDUSTRIES' REQUIREMENTS OF WATER have been estimated to be more than 150 billion gallons per day. Much of this water must be clarified to remove turbidity, color and other impurities before it is suitable for use. The continued growth and expansion of industry has often taxed existing clarification equipment. In addition, contamination of rivers, streams and other surface waters often complicate the coagulation problem.

New materials have been introduced in recent years that bring about remarkable improvement in many difficult coagulation problems. These materials are organic polymers that contain recurring units of small molecular weight, chemically combined to produce high molecular weight polymers. Each of these recurring units carries one or more electrical charges or ionizable groups. Because they are polymers and have the characteristics of electrolytes, they have been designated as polymeric electrolytes or more commonly, polyelectrolytes. Polymers that dissociate to form positively charged polymeric ions are classed as cationic polyelectrolytes. Polymers that produce negatively charged polymeric ions are classed as anionic polyelectrolytes.

## Coagulation and Floc Formation

Turbidity and color in natural water supplies are the main impurities normally encountered. Turbidity may be imparted by the presence of suspended matter or it may be due to a colloidal dispersion. Usually it is present in both forms. Color is mainly present in the colloidal state. Coarse suspensions will settle readily but the colloidally dispersed materials will remain suspended almost indefinitely. Table I illustrates the settling time required for particles of various sizes.

The theory underlying coagulation falls into the category of Colloidal or Surface Chemistry—a very complex subject. However, a brief description of the nature of a colloid's electrical charge will serve to explain the mechanism of coagulation and will also illustrate the role played by polyelectrolytes and coagulants in general.

The stability of a turbid water is attributed to the fact that colloidal particles carry the same charge. Identically charged particles repel each other, therefore, continued dispersion rather than precipitation is favored. The precipitation of colloidal particles, however, can be brought about by introducing ions of opposite charge. The relative precipitating power of ions increases markedly with increase in the ion's charge or valence. For example, the aluminum ion ($Al^{+++}$) is roughly 500 times as effective as the sodium ion ($Na^{+}$) for precipitating a negatively charged particle. Aluminum and ferric ions with three positive charges are the most commonly used coagulating ions. The polyelectrolytes with their recurring groups dissociate to form many electrically charged polymeric ions and their precipitating power is considerably greater than the precipitating power of the trivalent inorganic ions.

In addition to the mechanism of introducing ions of opposite charge to effect precipitation, the coagulant itself forms an insoluble, gelatinous precipitate or floc—such as aluminum hydroxide or ferric hydroxide—and this floc tends to agglomerate and absorb the turbidity and color particles. The settling rate is dependent upon the floc size, viscosity of the liquid medium (which is a function of temperature) and specific gravity of the floc micelle. Studies have shown that the specific gravity of the floc micelle is very greatly affected by the entrained water between the individual particles in the floc. The organic polyelectrolytes bridge together and greatly compress the individual particles so that less water exists in the micelle itself, thus creating a floc particle of greater density with a more rapid settling rate.

The number of contacts between individual particles per unit of time controls the rate of flocculation. Firmly bound particles better resist the shearing action of the fluid and permit more rapid agitation and faster floc formation. The polyelectrolytes produce tougher, larger and more uniform floc formation which in many cases can permit greater throughput from existing equipment.

## Coagulation With Polyelectrolytes

Colloidal clay, the presence of which is one of the major contributing factors to

**TABLE I** VELOCITIES AT WHICH PARTICLES OF SAND AND SILT WILL SUBSIDE IN STILL WATER 10° C. OR 50° F.

SPECIFIC GRAVITY = 2.65

| Diameter of Particle, in mm. | Order of Magnitude | Time Required to Settle 1 Foot |
|---|---|---|
| 10.0 | Gravel | 0.3 seconds |
| 1.0 | Coarse Sand | 3 seconds |
| 0.1 | Fine Sand | 38 seconds |
| 0.01 | Silt | 33 minutes |
| 0.001 | Bacteria | 35 hours |
| 0.0001 | Clay Particles | 230 days |
| 0.00001 | Colloidal Particles | 63 years |

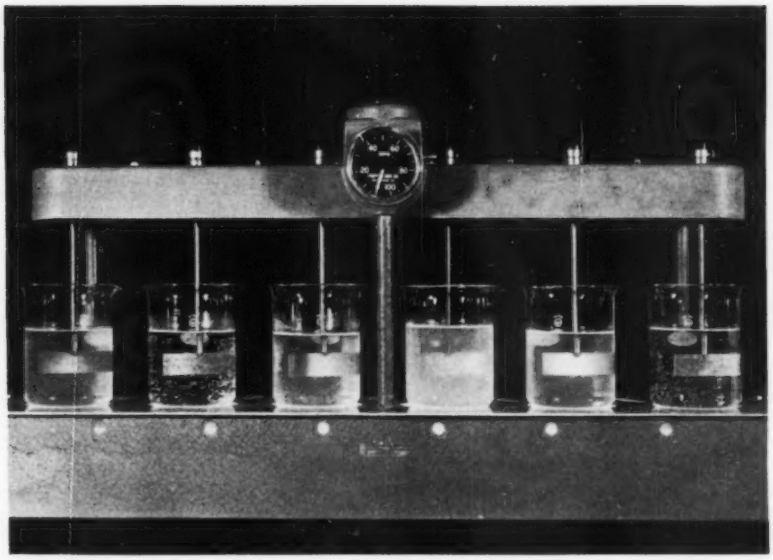

Figure 1—Jar tests in progress.

# TOOLS FOR COAGULATION

turbidity of raw water, invariably carries a negative charge. Cationic polyelectrolytes are very effective flocculating agents for clay suspensions. Anionic polyelectrolytes do not flocculate clay suspensions, since both the clay and the anionic polymer have the same negative charge. However, if aluminum or ferric ions are added to initiate the floc formation then the addition of an anionic polymer will materially aid in the rapidity of floc formation as well as increase the settling rate and toughness of the floc. In this case, the anionic polyelectrolyte serves as a coagulant aid, whereas, the cationic polyelectrolytes can function as primary coagulants in the absence of the metal ion coagulants or as coagulant aids when used with the metal ion coagulants.

## Jar Testing

When first considering the use of the polyelectrolytes as coagulants or coagulant aids, it is often best to employ a jar testing procedure. Jar testing apparatus is illustrated in Figure 1. The factors that are studied in a jar test are: pH, effect of various primary coagulants and coagulant aids, effect of weighting agents such as clay or calcite, and finally the effect of time and duration of agitation on the various combinations. The tests must be conducted systematically, changing one variable at a time, so that the best combination of primary coagulant, coagulant aid, weighting agent and pH may be determined. The criterion used in selecting the best combination is primarily based on the reduction or lack of turbidity and color in the supernatant water, together with the speed with which the floc forms, the characteristics of the floc and the speed of settling. Depending on the ultimate use of the water, chemical tests for residual aluminum and iron should also be used as a criterion. While the jar tests do not duplicate the conditions of the plant clarifier, they do serve as a good starting point for selecting the best combinations and treatment dosages required.

## Case Histories

The use of polyelectrolytes quite often permits substantial increases in capacities of water clarifying units. In many cases this has been accomplished at no increase in cost. In other cases, the cost of the polyelectrolytes has not been justified on a continuous basis, but only during periods when difficulties are encountered with normal coagulation procedures.

In one particular refinery in the midwest, a sludge contact, vertical clarifier was employed to treat river water for various plant requirements. The clarifier had been operating at a flow rate of 1,200 to 1,300 gpm, using lime and ferrous sulfate for coagulation.

Due to very heavy demands on the unit, it was decided to try a water soluble polymer in the coagulation process. An aid of the anionic type exhibited desirable results in extensive jar tests and was, therefore, tried on the commercial unit.

With the use of the polyelectrolyte aid, it was found that the flow rate through the unit could be increased to 2,000 gpm. The quality of the effluent water was superior at the higher rate than the quality obtained without the aid at the original lower rate. One of the side effects of the treatment was that the sludge bed was decreased in volume, due to the higher density of the floc. Blowdown was, therefore, set at a lower rate.

At a northern paper mill, operation of the clarifier at 170 gpm consistently produced an effluent of relatively high turbidity due to carryover of floc. With the use of a polyelectrolyte coagulant aid, an effluent of excellent clarity was produced consistently at a flow of 250 gpm. The turbidity of the effluent was reduced from 16 to less than 5 units with the polyelectrolyte. The sludge density was increased and blowdown was decreased. Over-all treatment costs were reduced from an original 7.7¢ per 1,000 gallons to 4.0¢ per 1,000 gallons, including the cost of the polyelectrolyte aid.

---

If you have a coagulation problem, BETZ Laboratories will be pleased to offer recommendations. Why not call in a BETZ Field Engineer today? He'll be happy to discuss the problem with you. No obligation, of course.

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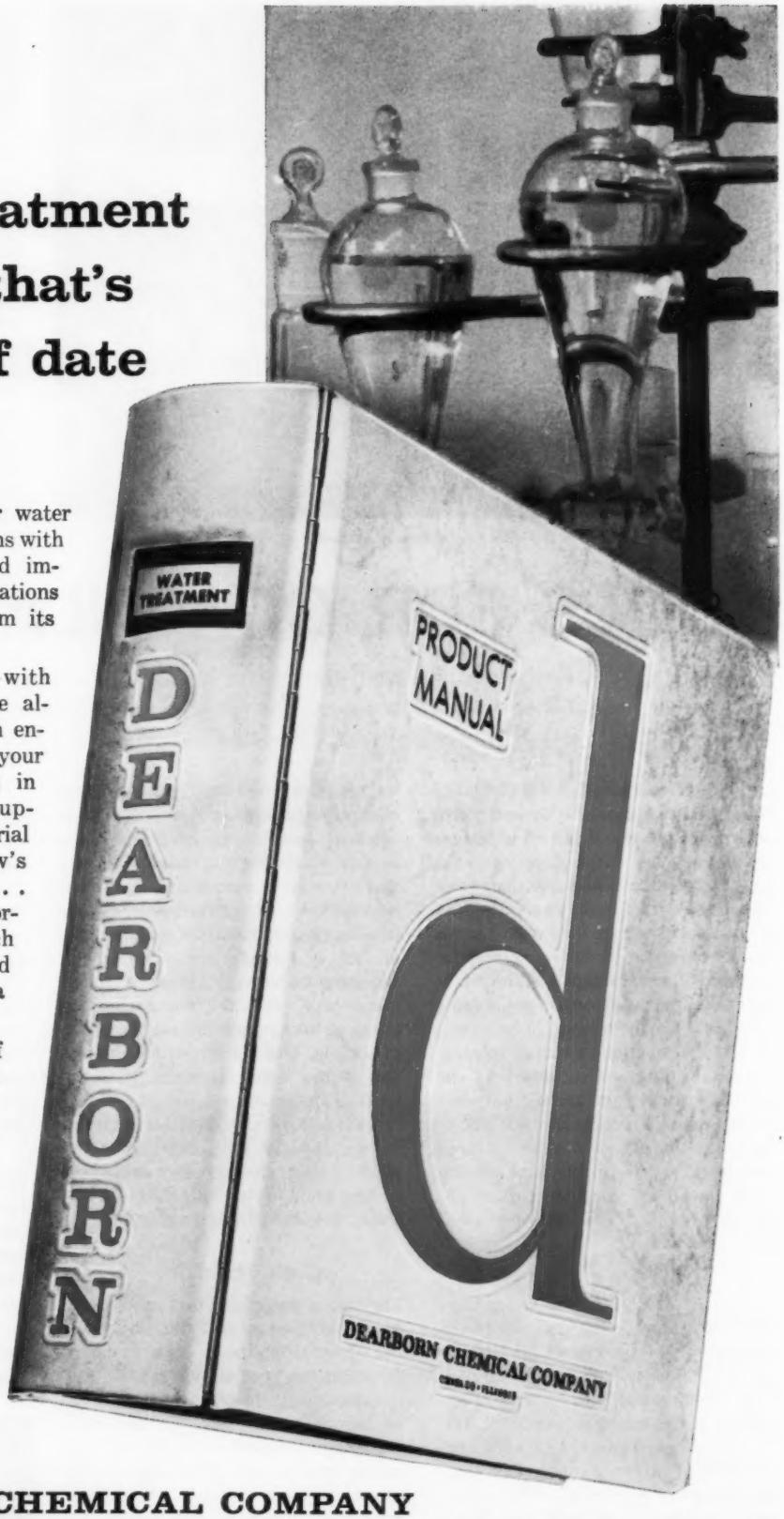


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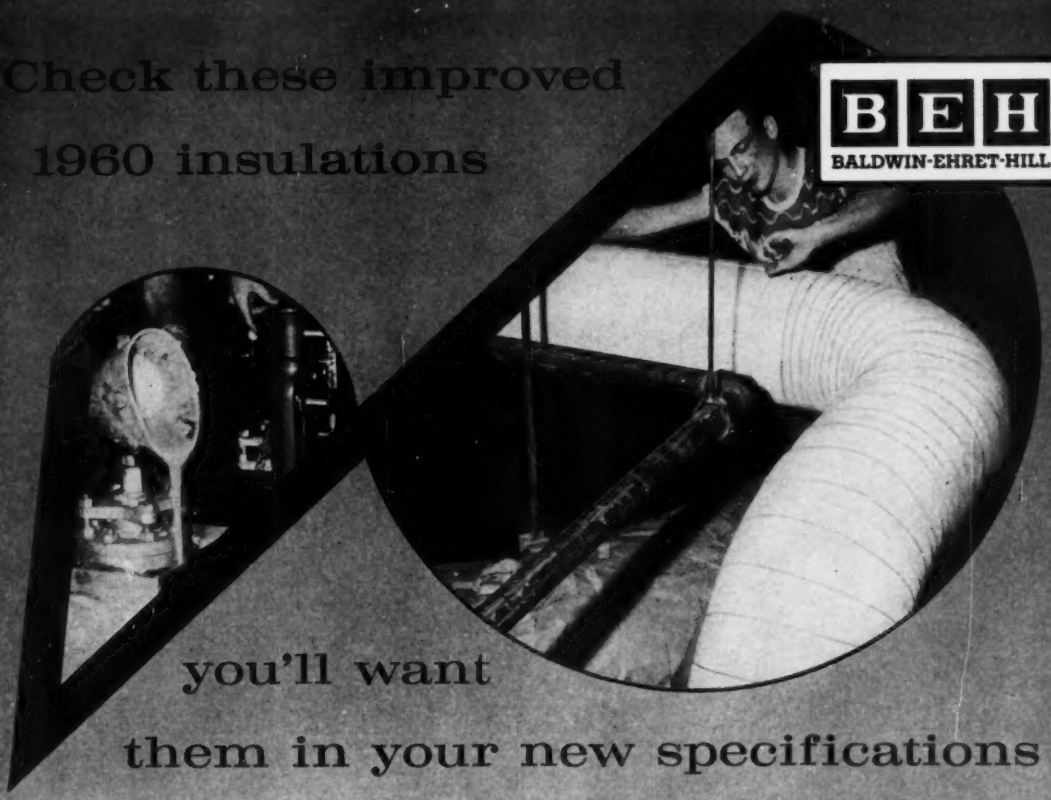

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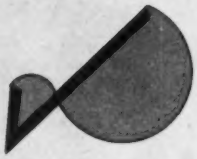

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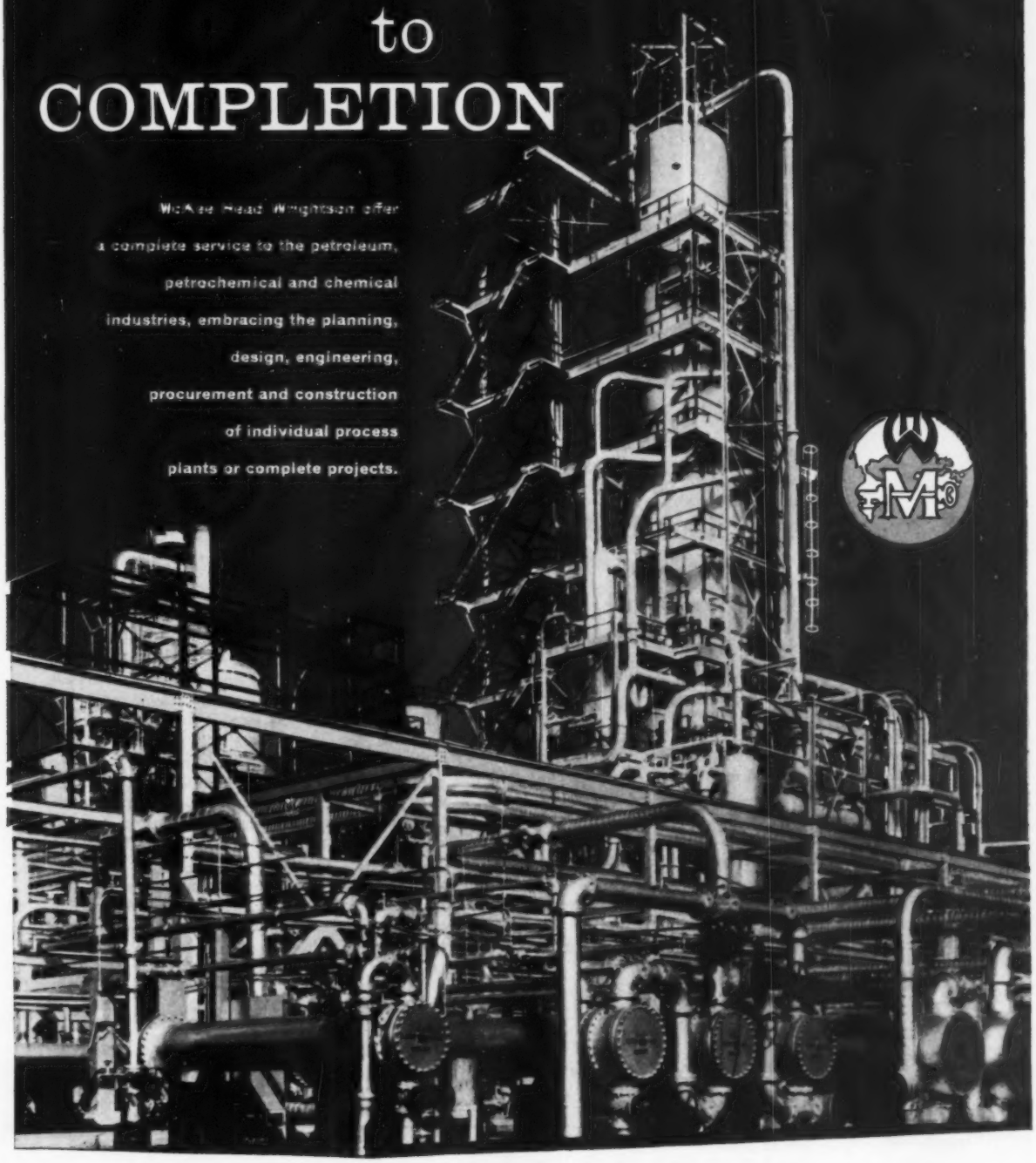

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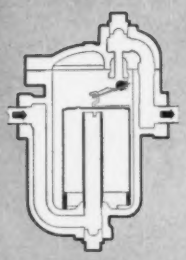
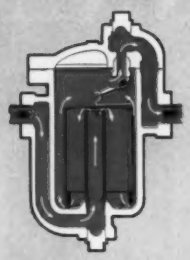
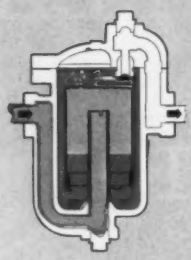
## This simple trap operating principle provides the efficiency, dependability and freedom from maintenance necessary for the most profitable use of steam



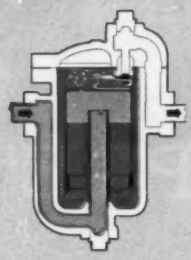
When trap is first installed, the inverted bucket is down and the valve is wide open.



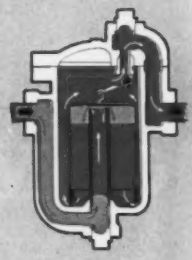
When steam is turned on, condensate (solid color) flows into trap and out through discharge orifice, until —



Steam (light color) reaching the trap floats the inverted bucket and closes the valve.



When more condensate enters the trap, the bucket loses buoyancy and pulls on valve lever.



When weight of bucket times leverage overcomes pressure on valve, bucket sinks and opens trap.

Key: condensate steam steam bubbles air bubbles

# ARMSTRONG INVERTED BUCKET STEAM TRAPS

## are designed and made to give you these big benefits:

● Amstrong Traps, the first inverted bucket steam traps, now represent the most advanced development of this time-proven principle. They provide all the advantages necessary for efficient, economical condensate drainage from virtually all types of steam using equipment.

1. *No steam loss* – Steam never reaches the orifice even when there is no condensate load.
2. *Automatic air elimination* – Vent in trap bucket passes air and other non-condensibles through to be discharged with condensate.
3. *No cooling leg required* – Condensate is discharged at steam temperature as fast as it reaches the trap because trap operates on difference in density between steam and water not on temperature.
4. *Operates on any back pressure* – Failure of one trap in system will not cause others to open because high back pressure does not affect an Armstrong trap other than to reduce capacity. As long as there is a pressure differential across the orifice the trap will close on steam and open for condensate.
5. *Unaffected by ordinary dirt* — Swirling action of condensate keeps dirt in suspension until discharged with condensate, prevents it from lodging in valve.
6. *Completely dependable* — Proved design plus the use of all stainless steel working parts assure continuity of service and length of service unmatched by any other trap.
7. *Big capacity in a small, economical package* — Armstrong design gives you the highest practical capacity for any given pressure. And remember, Armstrong capacity ratings are based on *hot* condensate at the *working pressure differential* stated, not on theoretical orifice capacities.

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860 Series for low pressure heating service.

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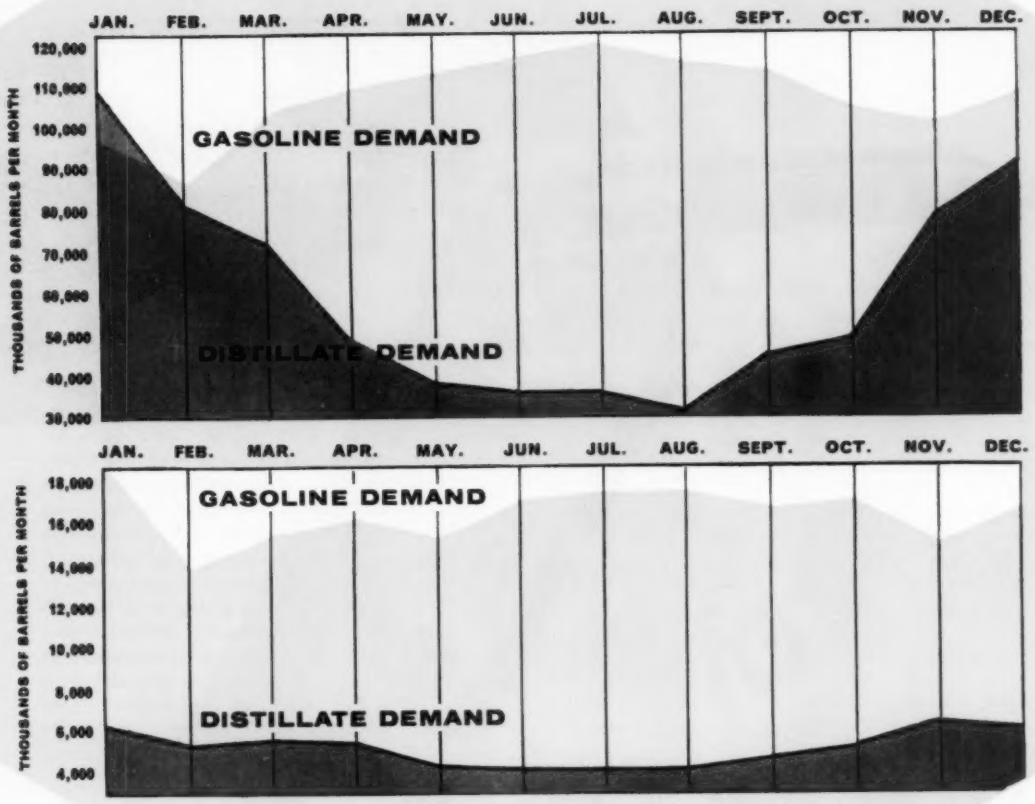


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. . . a fast-moving program of planned expansion, product development, and streamlined distribution to help our customers meet the challenge of the Soaring Sixties.

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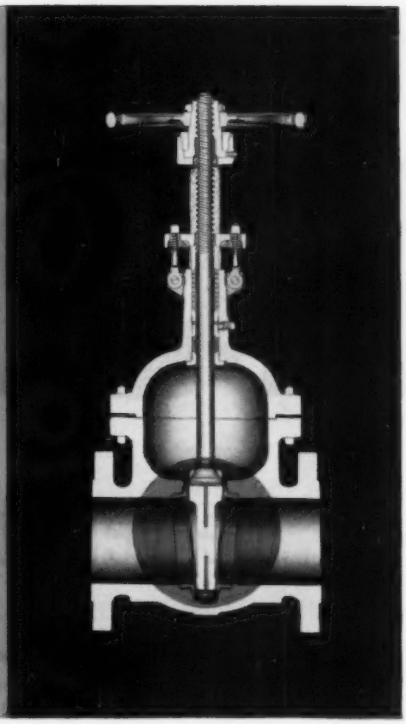

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**BECAUSE THEY'RE FLEXIBLE,** minor deflection of seating faces due to pipe strains does not affect tightness of Crane Flex Gates.

**BECAUSE THEY'RE FLEXIBLE,** new Crane Flex Gates are tight on inlet seat and outlet seat over a wide range of pressures.

**BECAUSE THEY'RE FLEXIBLE,** new Crane Flex Gates can be used singly in some services where two conventional gate valves are frequently specified. You can save substantially on piping costs.

**BECAUSE THEY'RE FLEXIBLE,** new Crane Flex Gates can be serviced—body seat rings replaced or seating faces refinished—quickly, and without painstaking accuracy. Slightly off-taper seats do not affect tightness or operating ease.

**BECAUSE THEY'RE FLEXIBLE,** new Crane Flex Gates will easily outperform any conventional solid wedge disc valve you now use. *And there's no increase in price.*

**BECAUSE THEY'RE MADE BY CRANE,** these new Flex Gates are completely dependable. You can use them with complete confidence on steam, water, gas, oil or oil vapor service. Stem and disc seating faces are Crane Exelloy. Shoulder-type body seat rings are Exelloy or Crane No. 49 Nickel Alloy. Sizes: 12 inch and smaller; 150- and 300-pound pressure classes.

Ask your Crane Distributor for full information on Flex Gates—and for data whenever you work with the products Crane makes. He has the newest in information and products. Crane Co., Industrial Products Group, 4100 South Kedzie Avenue, Chicago 32, Illinois.

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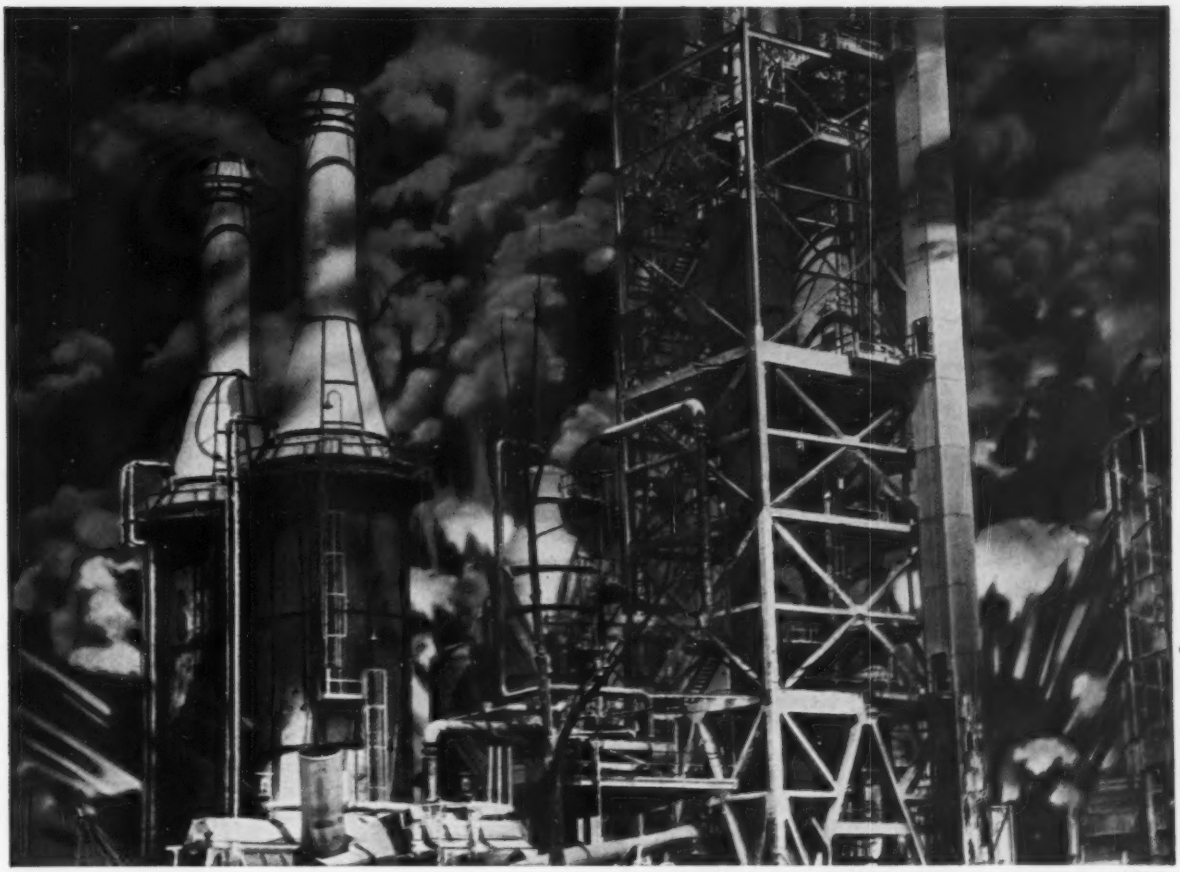

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After more than seventy hours of fire and explosion had spread from storage tanks to one of the world's most modern thermofor catalytic plants, damage was estimated at nearly 8 million dollars.

Yet the flames didn't destroy the entire plant. Vital equipment, key structural members and control areas . . . made fire safe by J-M's L. W. Blazecrete®. . . were virtually undamaged. This simple, low-cost protection paid for itself countless times over by providing an effective shield against 2 to 6 hours of direct flame exposure.

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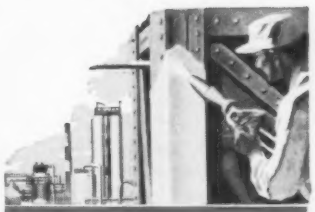
A hydraulic-setting refractory—Johns-Manville L. W. Blazecrete is quickly, easily applied to equipment and structural members . . . and to linings of high-temperature equipment. For troweling, just mix L. W. Blazecrete with water as you'd mix ordinary concrete—then slap trowel in place. When gunned, L. W. Blazecrete adheres readily with a minimum of rebound loss. Whether used for fire protection or for linings—L. W. *Blazecrete lasts!*

Find out more about this newest of fire protection ideas, and about the application of L. W. Blazecrete throughout the petroleum industry. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.



Gunned in place or slap troweled L. W. Blazecrete is the ideal material for refractory linings. It gives you an unusually strong, dense and homogeneous lining . . . ready for use within 24 hours.

**JOHNS-MANVILLE**

JOHNS-MANVILLE JM PRODUCTS

# A Nalco PRODUCT MANAGER

## Answers Questions About Refinery Equipment Fouling And Successful Anti-Fouling Programs

### Both Organic and Inorganic Deposits in Refinery Equipment Raise Operating Costs, Decrease Throughput

Corrosion control, desalting, oxygen scavenging, gas blanketing and adjustment of process variables will help to reduce exchanger fouling—but in many systems, fouling continues to cause trouble. Here are some of the questions that are asked, and the answers we had to find to them in order to develop anti-fouling programs of real value to refineries.

**Question:** What causes fouling in refinery systems?

**Answer:** Inorganic salts, corrosion products and organic polymers. Inorganic salts are carried into exchanger trains by water dispersed in the hydrocarbon, and deposit out as the water is vaporized on heating. Corrosion products may be carried into exchangers from other units, or corrosion may occur in the exchangers themselves. Organic polymers are insoluble, polar, high-molecular-weight materials, formed as the hydrocarbon is heated.

**Question:** Where does fouling occur?

**Answer:** Fouling may occur in virtually any part of a refinery system; however, these are the areas where fouling is usually most troublesome: heat exchangers and furnaces ahead of catalytic and thermal cracking units, reforming units, and crude units, fractionating towers, reboilers and overhead condensers. Types and amounts of deposits vary, depending on the charge stock, corrosion control measures, and process variables.

**Question:** Why is an anti-fouling program necessary?

**Answer:** Because of the high cost of processing in fouled equipment, created by: reduced heat transfer; lowered throughput; downtime; and direct cleaning costs.

**Question:** How does Nalco solve fouling problems?

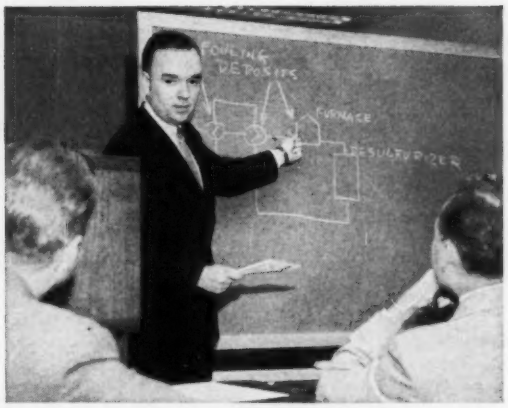
**Answer:** By making a careful analysis of the system, locating units where fouling occurs, and finding the sources of fouling. When these facts are available, recommendations are made for an anti-fouling program.

When the program is in operation, Nalco field representatives maintain close contact with operating personnel, cooperating to secure continuously successful, economical results.

**Question:** What is Nalco's anti-fouling program?

**Answer:** It is a program designed for a specific refinery system to eliminate corrosion, organic polymer formation, and any other sources of fouling. Where fouling is due to potential deposit-forming materials in charge stocks, Nalco-developed chemicals are recommended to stabilize and disperse these materials.

Usually anti-fouling additives are used in combination with Nalco corrosion control chemicals; and, where indicated, following Nalco desalting chemicals.




**R. C. Canapary, Product Manager, Petroleum Industry Chemicals Department, Nalco, is a Doctor of Chemical Engineering, whose experience includes technical and engineering work at Nalco, as well as several years with a major oil company.**

The assistance of Nalco representatives in regularly recording and evaluating the effects of temperatures, heat transfer rates, pressures, and other process variables helps to assure optimum results in operating efficiency and treatment economy.

Research and development work is a continuing part of the Nalco anti-fouling program. Nalco researchers use specially-designed equipment to simulate plant operations. Conditions can be established to accelerate fouling rates and speed development of promising new chemicals.

**Question:** How long does it take to establish the Nalco anti-fouling program?

**Answer:** A Nalco anti-fouling program can begin promptly at your request. Nalco considers a program established when anti-fouling and corrosion control results are proven satisfactory.

The electrical resistance method of corrosion evaluation, corrosion coupons, iron-in-water tests, operating records (temperature, pressure, heat transfer coefficients) and direct inspections should be used to evaluate the program's effectiveness.

**Suggestion:** Get full details on a Nalco anti-fouling program for your operation. For quick action, call your Nalco Representative, or write to me at Nalco: Dr. R. C. Canapary, Product Manager, Petroleum Industry Chemicals Department.

**NALCO CHEMICAL COMPANY**
**6259 West 66th Place • Chicago 38, Illinois**
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# 65,000 GALLON PER MINUTE HUDSON COOLING TOWER SUPPLIED IN EMERGENCY

Faced with shutdown of process units because of a damaged, partially inoperative cooling tower, a large Gulf Coast oil refiner called upon HUDSON for emergency supply of new cooling capacity. Despite necessity for modification of HUDSON standard design to conform to existing foundation, and though working under adverse condition of stepwise removal and replacement of partially operating old tower, more than 30 percent of the new HUDSON tower was operating in less than five weeks. The promised time schedule was met, the crisis averted, and guaranteed cooling performance exceeded.

Performance of such special services with speed, ability and integrity is a measure of the quality of HUDSON service — whether in repairing or replacing an operating cooling tower, or in designing and supplying a complete integrated system with balanced use of water and direct air for cooling all process streams.

In addition to water cooling towers, HUDSON designs and manufactures SOLO-AIRE units (for cooling solely with air), and COMBIN-AIRE units (for cooling with combination of maximum air and minimum water). Avail yourself of HUDSON's years of experience in integration of these all-encompassing categories of equipment into cooling systems utilizing optimum ratio of air and water balanced to best meet specific conditions of climate, process, and water availability and quality.

**ONLY HUDSON OFFERS — — — —** process stream cooling systems integrating cooling towers, Solo-aires and Combin-aires for optimum balance of air and water cooling.

*It will pay to consult Hudson during processing design stage of new projects.*

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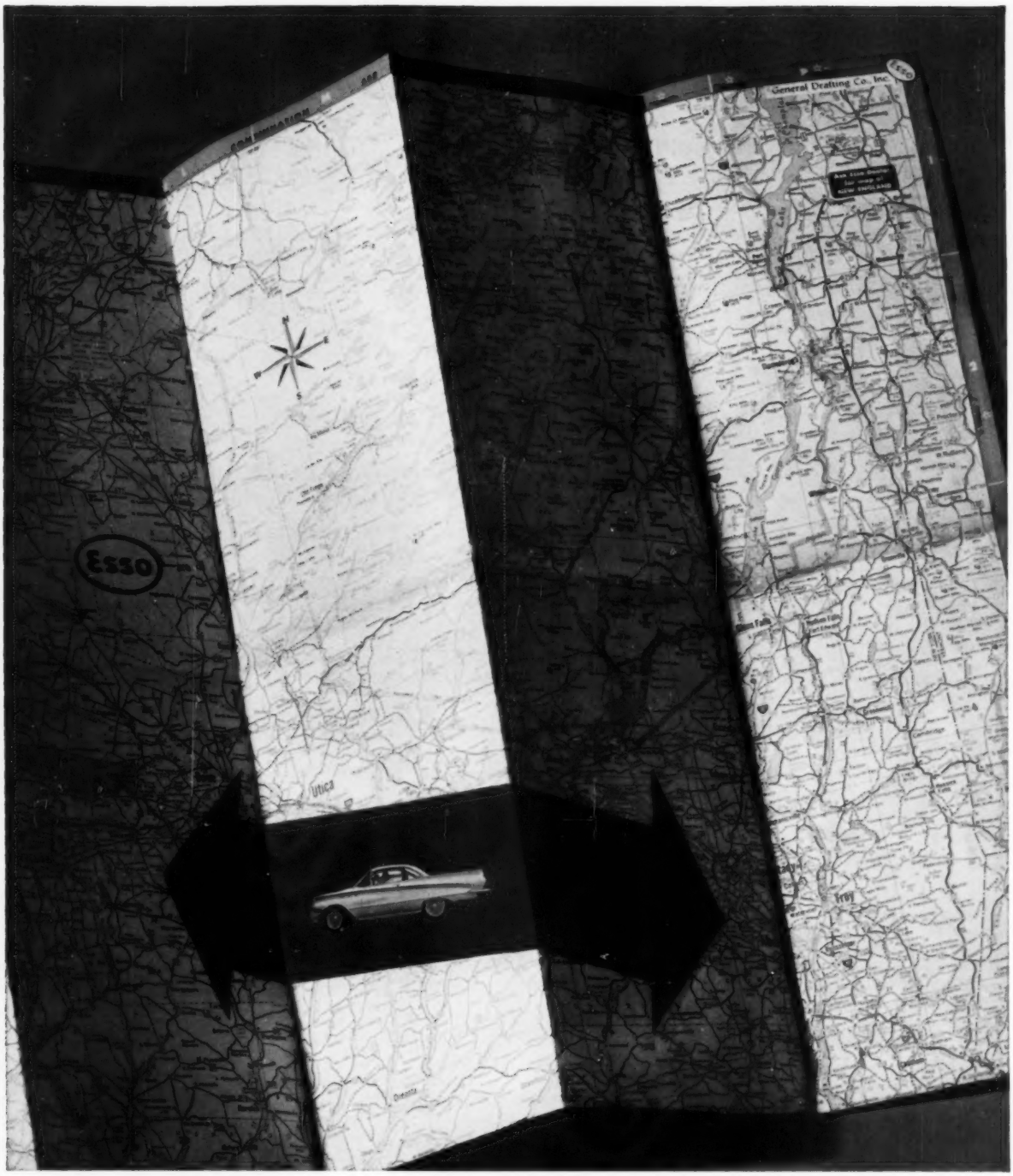


"If every car traveled another 100 miles a year, U. S. gasoline consumption would rise one per cent. This means only another two to three hours of driving each year, or less than four more minutes a week behind the wheel. Yet one per cent is about 10 million barrels of gasoline a year!... The API program to promote more travel deserves the backing and support of every branch of the industry."

—M. J. Rathbone, President

**Standard Oil Company (New Jersey)**



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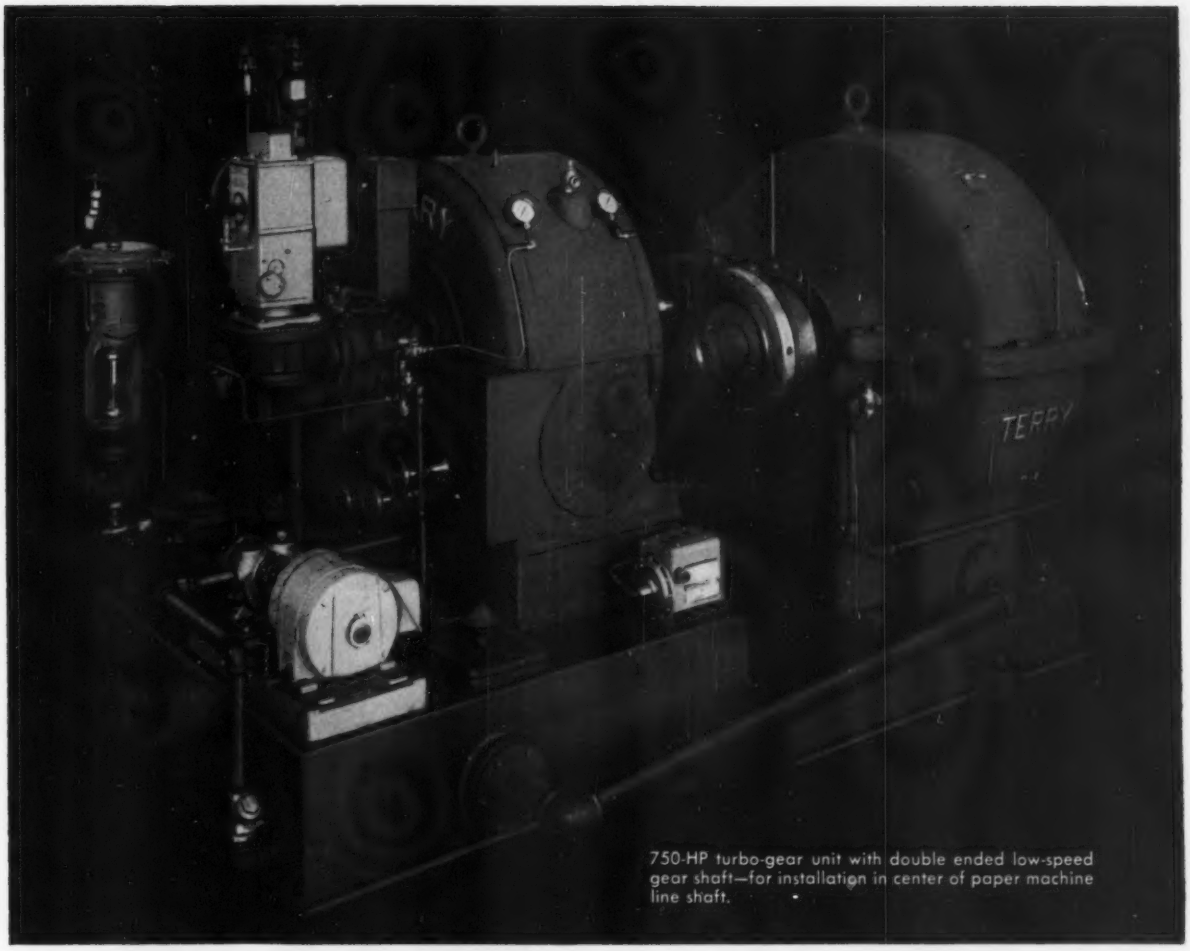


750-HP turbo-gear unit with double ended low-speed gear shaft—for installation in center of paper machine line shaft.

# LOW-SPEED TURBINE DRIVES

## *tailored to meet your requirements*

For more than half a century, Terry has been one of the principal suppliers of turbo-gear units for driving slow-speed fans, generators, paper machines, large pumps and the like. Each unit is designed to meet the job requirements. The paper-machine drive illustrated is a good example of this *individualized engineering*.

In service at a large southeastern paper mill, the unit delivers 750 HP at 3350/500 RPM, with steam conditions of 450 lbs., 660°F and 50 lbs. back pressure. Equipped with a variable-speed governor, operated by remote control, the speed of the unit may be varied through a 10:1 range. Other features include forced-feed lubrication to turbine and gear bearings, and automatic shutdown and alarm in case of low oil pressure.

Whatever *your* requirements for low-speed turbine drives, a Terry engineer will be pleased to discuss them with you. Bulletin S-140 covers the full line of Terry turbines; Terry gears are described in bulletin S-130.

**THE TERRY STEAM TURBINE CO**
**TERRY SQUARE, HARTFORD 1, CONN.**

TERRY

TT-1212



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# stays on the line L·O·N·G·E·R!

Nothing, but nothing — in this world or the next — stays on the "line" longer than SMITH Forged Steel Valves. That's why they are used today in a large percentage of the major Refinery, Chemical and Petrochemical plants in both this country and Canada. The extra stamina and strength built into all SMITH Valves is not there by accident. It is there by design — a combination of new ideas and special features suggested by leading engineers — the men best qualified to know the solution to the valve problems of their respective industries. You can rely on SMITH Valves to do a better job in meeting the mounting challenge of pressures, temperatures and corrosion. We will be glad to send you detailed information on the complete line of SMITH gates, globes and needle valves.

Smith "Figure 800" O S & Y Gate Valve Sizes: ¼" - 2" incl.

**smith** FORGED STEEL **valves**

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# Oakite ECP
engineered cleaning program

# soak tank method cuts bundle cleaning costs 70%

Clogged almost solid with caked-on carbon, heat exchanger tube bundles took their toll on muscles and cleaning budget at one refinery. Hand sawing just one 60-tube, 12-foot bundle cost $392 in labor alone.

Refinery engineers called in the Oakite man. The ECP for this refinery included a recommendation to soak exchanger bundles in a hot solution of Oakite Compound No. 85. Now, there's no back-breaking manual labor needed. Bundles come out of the tank far cleaner than when handled manually, and the cost *per bundle* is only $120 including labor and Oakite material.

**WHAT IS OAKITE ECP?** It's an *Engineered Cleaning Program* that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by *materials* known to make short work of refinery soils, by proved *methods*. Send for booklets. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

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**Oakite ECP**
*your economy key*



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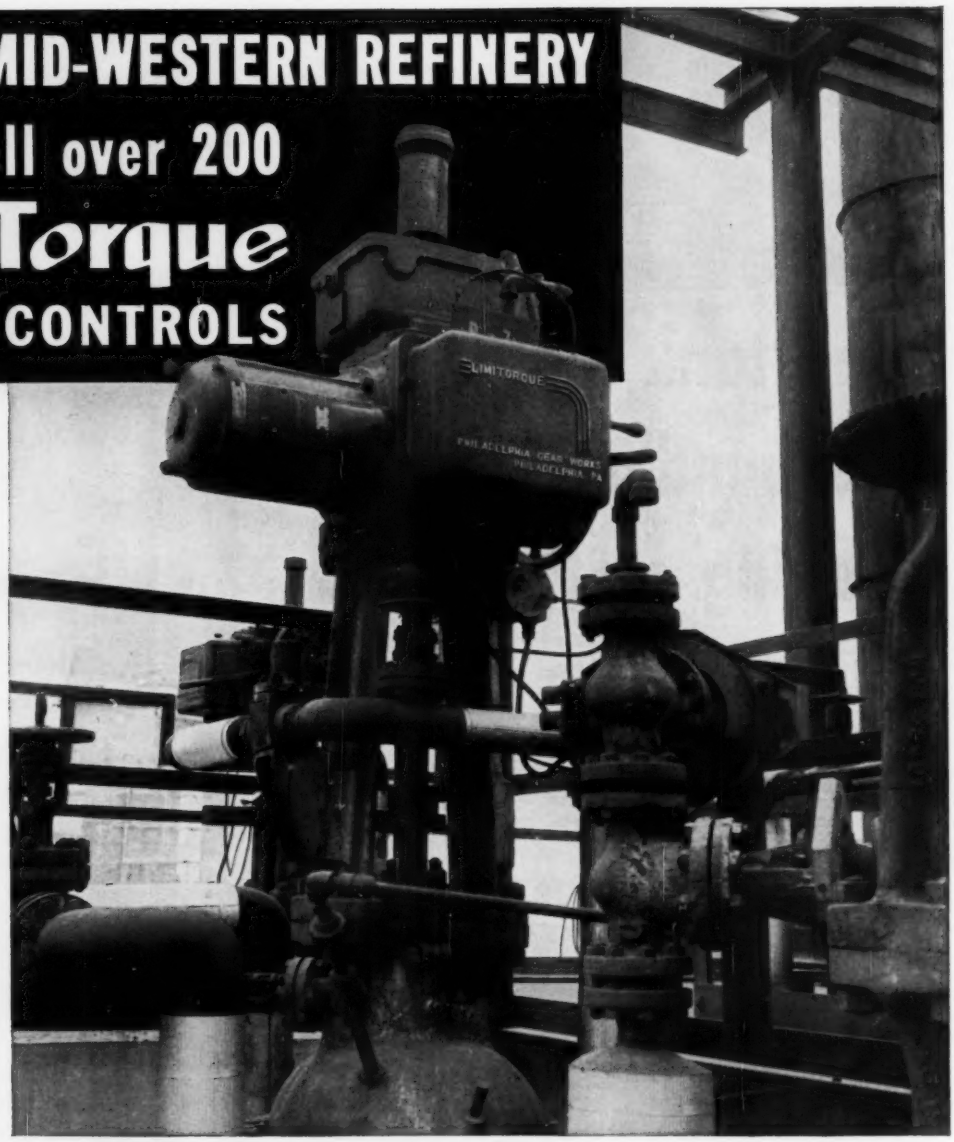
# LARGE MID-WESTERN REFINERY uses well over 200 LimiTorque VALVE CONTROLS




## . . . on Platinum Catalyst Reforming Units

The above illustration shows a LimiTorque Motorized Valve Control mounted on a 12″, 600 lb. valve on a platinum catalyst reforming unit . . . This is just one installation of well over 200 such units used in this modern, well known refinery, and is but one of many thousands of LimiTorque controls used throughout the refinery field in America and foreign countries.

These LimiTorque units are of explosion-proof design having motors with Underwriters Labels . . . They are also equipped with position indicators which transmit valve position back to the control point.

There is no guesswork or labor connected with the LimiTorque Valve Controls . . . from a conveniently located control point, one key man can open and close any type of valve quickly and dependably in remote or hazardous locations.

LimiTorque may be actuated by any available power source, such as Electricity, Oil, Gas, Water or Air; and is available for Microwave control.

*Send for Catalog L-550 for details.*

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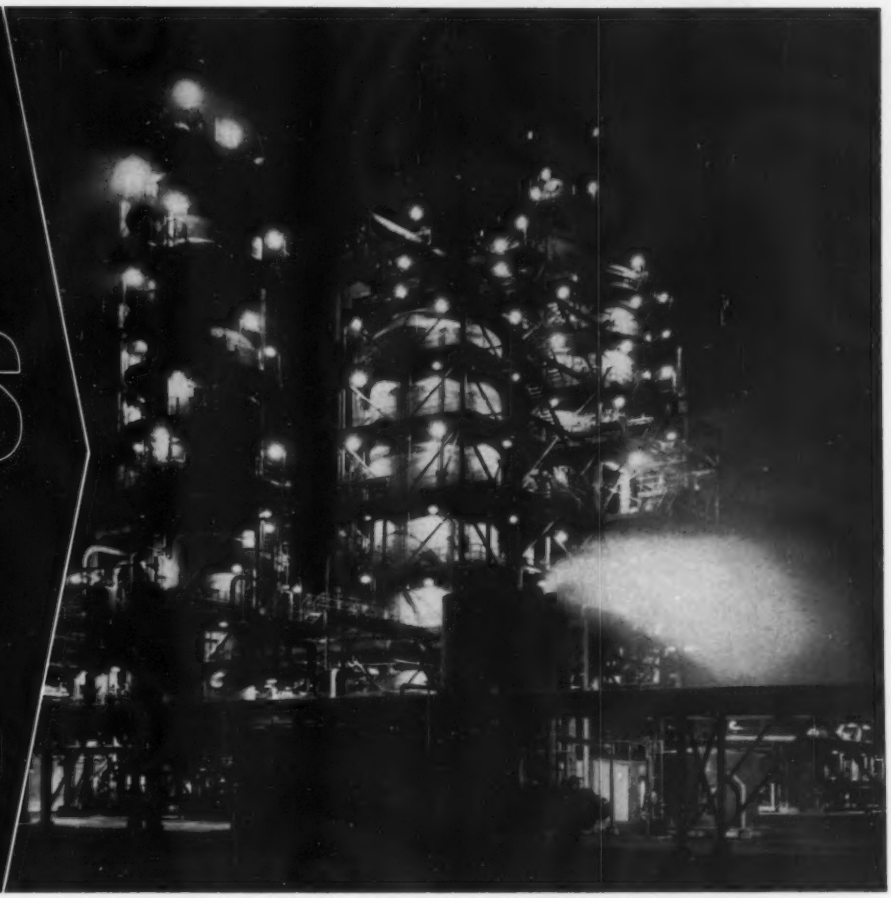
# HOW TO PUT A PLUS FACTOR IN YOUR COATING PROGRAM



Every good Maintenance Supervisor looks for something extra — a plus factor — when he chooses the coatings for his program. You'll find it in Napko Industrial Coatings, high quality, durable coatings with the longest life span possible, *plus* responsible follow through.

During and after most applications of Napko coatings, you'll find a highly trained, well qualified Napko Sales Engineer carefully inspecting the coating to make sure you get what you pay for, whether it's at the top of a stack or inside a storage tank; this is responsible follow through, the crucial ingredient that doesn't come in the can. There's no substitute for it.

If you have a corrosion problem — unique or commonplace — there's a Napko Industrial Coating to do the job and a Napko representative ready to help you solve your problems and make sure you get the most for your money. Help yourself by contacting your Napko industrial division.

Write or call today.

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1. Climatic-Operational Analysis
2. Lab Testing & System Research
3. Field Testing
4. Paint Crew Training
5. Job Inspection in Progress
6. Case History for Repaint

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**INDUSTRIAL COATINGS DIVISION**

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*'62 could be the year for you!

## YOU WIN BEFORE YOU START...

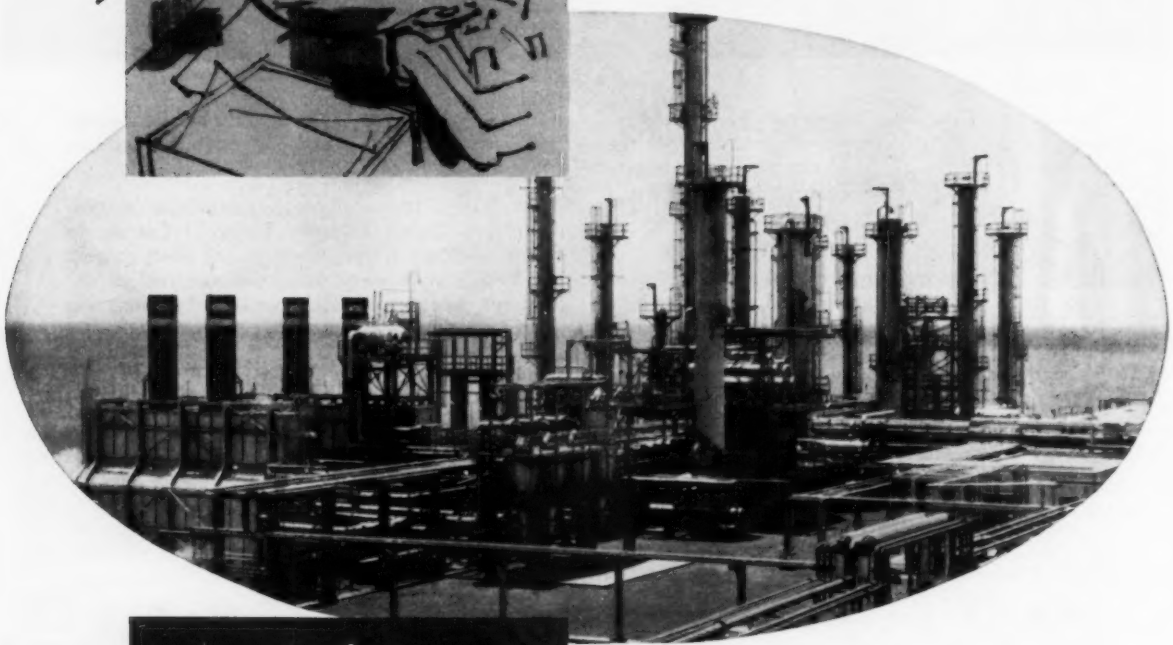
It's a long road from blueprint and flow chart to efficient plant performance. It takes an intimate knowledge of the route to assure safe and timely arrival.

To show where you're headed before you start, Procon presents an accurate picture of what will be provided for every penny invested.

Regardless of where or what the client plans to build . . . petroleum, petrochemical or chemical process facilities . . . Procon prepares a firm proposal covering every detail of construction.

Before planning new construction, consult Procon. It pays . . . in superior construction and assured plant performance.

***A SUBSTANTIAL INCREASE IN PROCESS CAPACITY will be needed by 1962, according to reliable estimates . . . NOW is the time to start your planning!**



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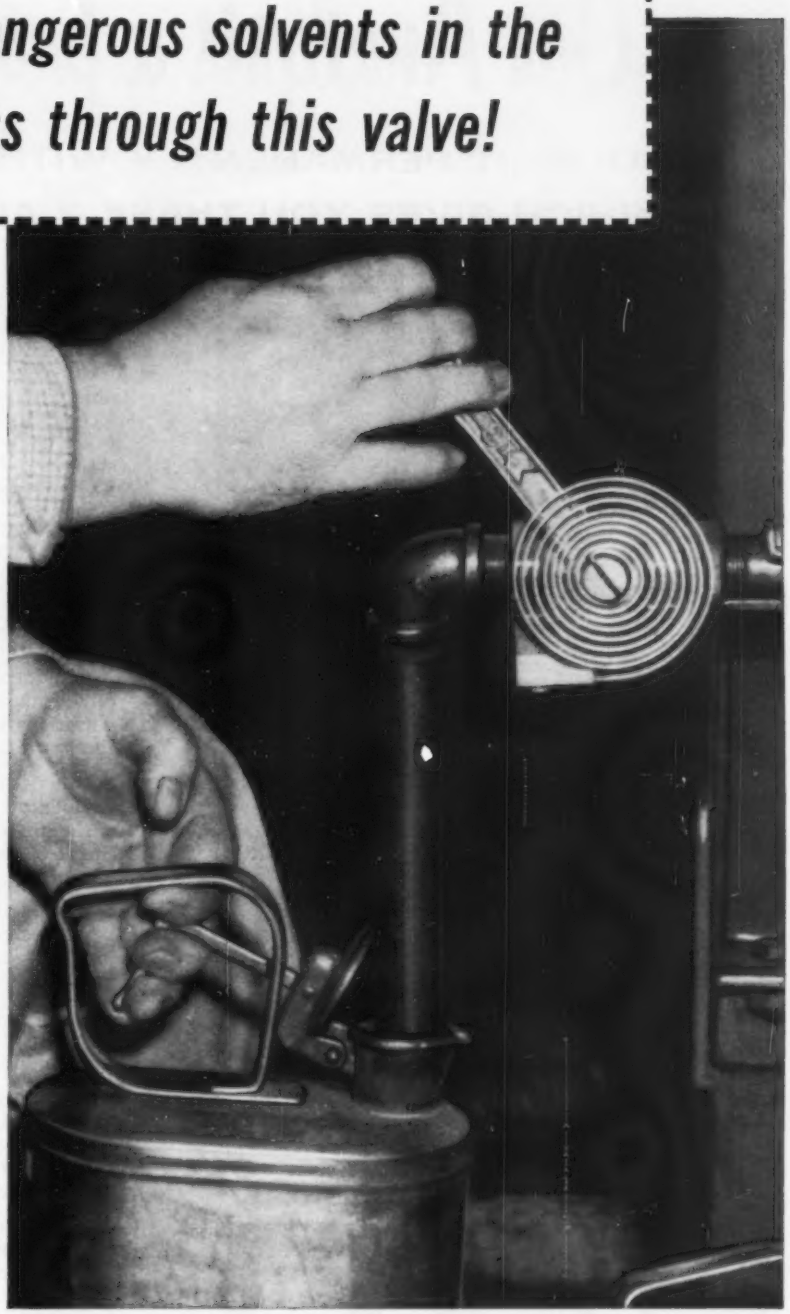
# *The most dangerous solvents in the world pass through this valve!*



But it's a *safe* passage. The ROCKWOOD ¾" (Fig. 802) Self-Closing Ball Valve is designed for *smooth, leakproof* handling of highly flammable liquids. A Rockwood Exclusive!

Take a typical installation at an experimental station of one of the nation's largest chemical companies. Here 36 different solvents, ranging from acetone to xylene, are dispensed from bulk containers. All types of self-closing valves were tried and evaluated for this critical job. None equalled ROCKWOOD for positive performance.

Unique ROCKWOOD Full Round Flow design holds turbulence to an absolute minimum — keeps static at a low level. Flash potential is negligible, greatly reducing fire hazard. In addition, the exclusive "*Spring Pressure* Compensation" keeps ball and seat in snug contact — assures leakproof, dripless shut-off, compensates for wear. Bronze valve body and Teflon trim resist corrosion. After 11 months and 103,200 open-and-shut cycles the company reports: trouble-free operation since installation.

Be as safe and sure with your solvent handling. Send coupon for complete details on the ROCKWOOD Self-Closing Ball Valve. Tested and listed by Underwriters' Laboratories, Inc.

**ROCKWOOD BALL VALVES**

***FULL, ROUND FLOW***

***Distributors in all principal industrial areas***

**ROCKWOOD SPRINKLER DIVISION**
*of The Gamewell Company • Subsidiary of E. W. Bliss Company*
221 Harlow Street, Worcester 5, Massachusetts

Please send me complete details on the ROCKWOOD ¾" (Fig. 802) Self-Closing Ball Valve.

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*Company* .....
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*City* ..... *Zone* ..... *State* .....



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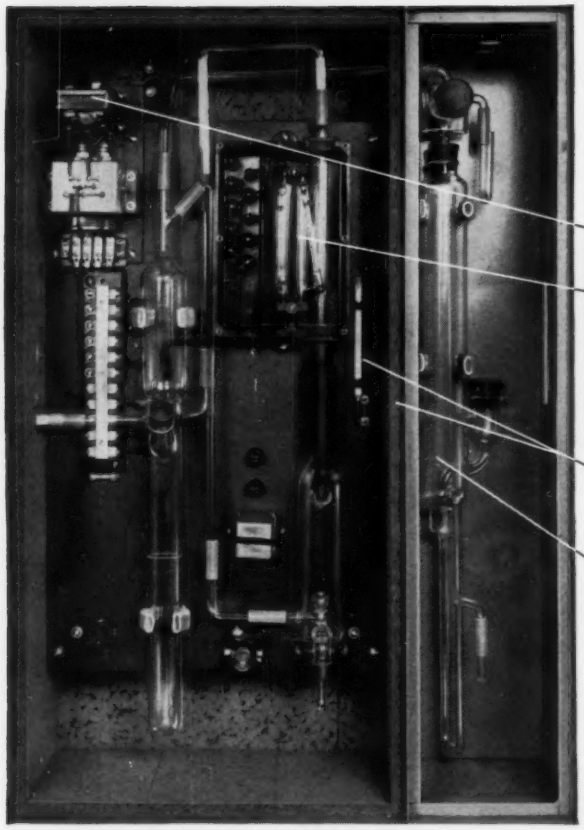
# Gas Analysis a problem?

## SOLVE IT PERMANENTLY WITH EQUIPMENT WHICH GIVES YOU THESE 7 ADVANTAGES



*Thermal Conductivity Analyzer*

In hundreds of plants, L&N's Thermal Conductivity Gas Analyzers are solving the problem of obtaining accurate, reproducible measurements of $CO_2$, $SO_2$, $H_2$ in $N_2$ and many other gases. Because they embody the benefits of thirty years' experience in process gas analysis applications, L&N Thermal Conductivity Analyzers . . . . .

**1.** Eliminate gas measurement upsets. A constant voltage regulator excludes a-c power variations.

**2.** Provide accurate measurements by using the unique L&N cell design which gives you vibration-free operation due to a rigid filament support . . . electrical stability by using a platinum filament . . . high corrosion resistance due to glass coating of the filament . . . and immunity to small flow variations because the cell is designed to utilize the gas diffusion principle.

**3.** Make reproducible measurements possible. Ambient temperature swings are eliminated by enclosing cell assemblies in an insulated case with thermostatically-controlled temperature.

**4.** Permit low maintenance and therefore minimum downtime as a result of the time-tested analyzer design including features such as flexible junctions, heavy glass construction, etc. Coal and asbestos filters remove mist and dust to assure cleanliness of the analyzer system.

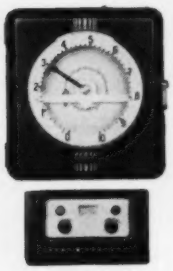
**5.** Match the inherent accuracy and sensitivity of null-balance Speedomax® G and H Recorders.

**6.** Permit selection of the particular type of control forms to fit the process. These include electric control, electro-pneumatic, and all-pneumatic controls—each designed to work with the Analyzer-Recorder system for maximum throughput.

**7.** Gives you undivided responsibility. The entire thermal conductivity system . . . sampling system, analyzer, recorder-controller . . . is designed, engineered and built by one organization with a nation-wide sales and service staff.

These "plus" features of L&N's Thermal Conductivity Gas Analyzers can help satisfy your demands for top quality products which lead to substantial savings. An eight-page booklet, Folder ND46-91(6) giving data on this equipment, is available by writing to Leeds & Northrup Company, 4923 Stenton Avenue, Phila. 44, Pa.

*Speedomax H Series 60 Electric Control*



*Speedomax G Series 60 Electro-Pneumatic Control*

*Speedomax G Pneumatic Controller*

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**CHIKSAN**

Written by engineers and well illustrated, this file contains a wealth of useful information on the application of swivel joints in line design. You'll find facts and figures on torque, geometric characteristics, thrust and radial loads. There's information on how to approach design problems and a quick comparison between swivel joints and other flexible devices. And, you'll find a group of actual installation reports with diagramatic drawings showing how the swivel joints were applied in the system. Be sure you have a copy of "Facts you should know about Swivel Joints" in your possession. Write Chiksan for your file today.

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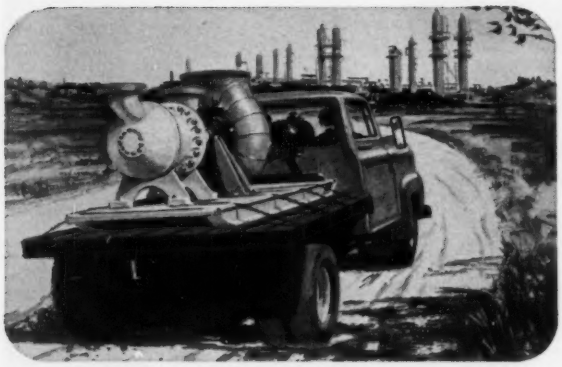
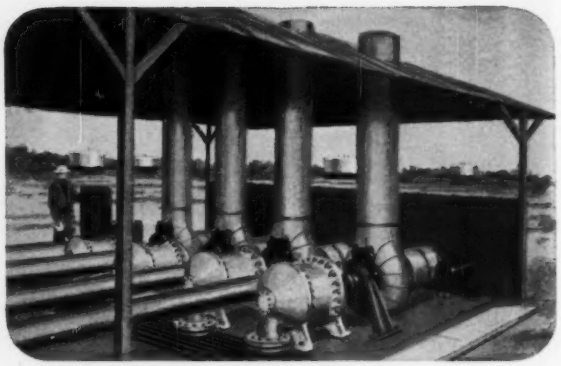
# Petroleum industry benefits with Solar turbomachinery



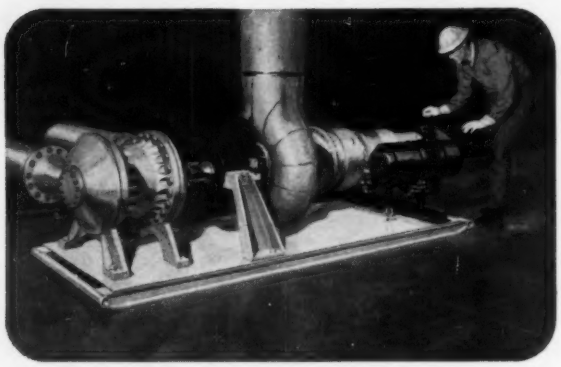
## 1. Easily transported

Because they are smaller and lighter than conventional power plants, Solar gas turbines are easily transported for original installation, or to a central shop for periodic maintenance. And the basic power plants, or generator sets, compressor units, and similar applications, can be inexpensively adapted for portable use.



## 2. Low cost installation

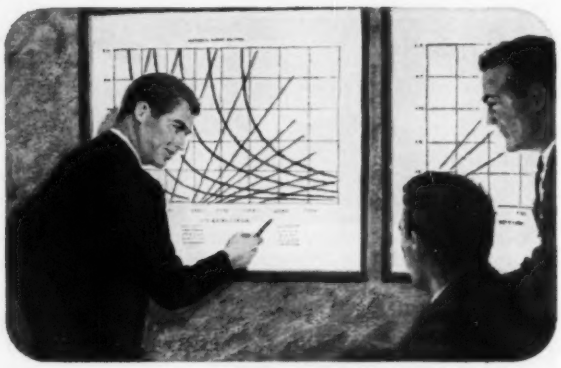
The same light weight and small size that makes transportation simple, also cuts the cost of installing Solar gas turbines and turbomachinery. Minimum vibration makes possible skid mounting or the use of present light foundations – you avoid heavy construction costs and install these units quickly without special labor requirements.



## 3. Simple maintenance

Solar gas turbines are simple in design, with few moving parts. They are easier to maintain than diesel or gasoline engines. Down time is cut to a minimum. Features such as interchangeable compressor wheels in Solar compressor units make quick field changes possible. Solar turbomachinery is designed for long, trouble-free life.

SOLAR
AIRCRAFT COMPANY



## 4. Low over-all cost

Whether you consider the capital cost of installed horsepower, or operating and service costs per installed horsepower, you will be pleasantly surprised when you measure Solar gas turbines against competing installations. We'll furnish the facts and figures you need on request. Solar builds turbines and turbomachinery to rugged industrial standards, for electrical power generation, gas compression, pumping, boat and vehicle propulsion, and for many special applications. Solar gas turbines range in size from 50 to 1250 hp.

You should investigate the profitable use of Solar gas turbines and turbomachinery. Write to Solar Aircraft Company, Dept. H-135, San Diego 12, Calif., for brochures or for information about specific applications.

**SALTY STORY** – To supply its constant needs for great quantities of cooling water, Tidewater Oil Company's Delaware refinery taps a tidal river for a maximum of 360,000 gpm. Salinity runs as high as 30,000 ppm, so Ni-Resist valves are used because of their excellent resistance to corrosive attack.

# Corrosion by cooling water tamed by Ni-Resist irons

**Corrosion is a major menace** to any refinery – but it poses an *additional* problem to some.

These are refineries that have little choice in the way of cooling water. Many coastal plants operate with water that is salty enough to eat the heart out of pumps, pipes, valves and other equipment in short order.

**A neat way** to put the Indian sign on such corrosive water is through the use of Ni-Resist* irons, a group of high-nickel alloy cast irons containing sufficient Nickel to produce an austenitic metal structure as well as a complete change in the chemical and physical characteristics.

The range of applications of Ni-Resist irons in corrosive service is broad. Their dependability has been well proved for valves, valve stem bushings, fittings, pump parts and other items of refinery equipment.

**No other cast metals** provide such a unique combination of useful engineering properties:

- **Corrosion resistance greater than that of unalloyed or low alloy cast irons and steels**
- **Excellent resistance to cavitation erosion**
- **Wear resistance**
- **Heat resistance**
- **Low temperature stability**
- **High order of castability . . . . . machinability . . . weldability**

No brief message such as this could possibly cover *all* the advantages of Ni-Resist irons. Nor can it detail their excellent resistance to destructive attack by corrosive crudes, salt water and refinery corrosives. We have an informative and valuable 70-page illustrated booklet that tells lots more. Called *Engineering Properties and Applications of Ni-Resist Irons*, it's free on request and well worth having. Write for a copy *today*.

*Registered trademark

**THE INTERNATIONAL NICKEL COMPANY, INC.**
67 Wall Street INCO New York 5, N. Y.

# NI-RESIST

## NICKEL MAKES ALLOYS PERFORM BETTER LONGER



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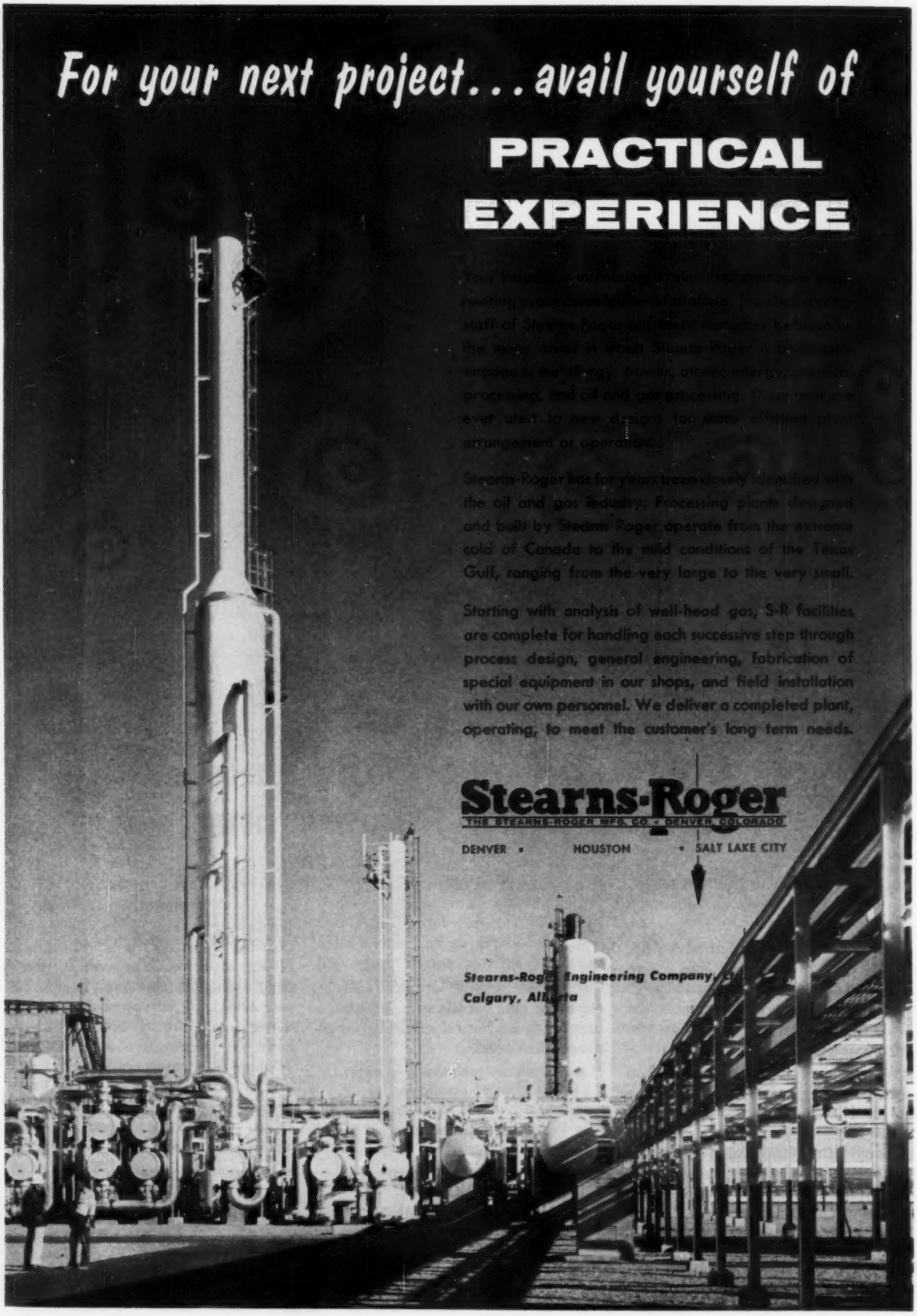
# For your next project... avail yourself of

# PRACTICAL EXPERIENCE



Your inquiry is welcome. Years of experience in engineering procedures lie behind us. The experienced staff of Stearns-Roger and Stearns-Roger Canada in the many areas in which Stearns-Roger is presently engaged: metallurgy, power, atomic energy, chemical processing, and oil and gas processing. Here you will ever alert to new designs for more efficient plant arrangement or operation.

Stearns-Roger has for years been closely identified with the oil and gas industry. Processing plants designed and built by Stearns-Roger operate from the extreme cold of Canada to the mild conditions of the Texas Gulf, ranging from the very large to the very small.

Starting with analysis of well-head gas, S-R facilities are complete for handling each successive step through process design, general engineering, fabrication of special equipment in our shops, and field installation with our own personnel. We deliver a completed plant, operating, to meet the customer's long term needs.

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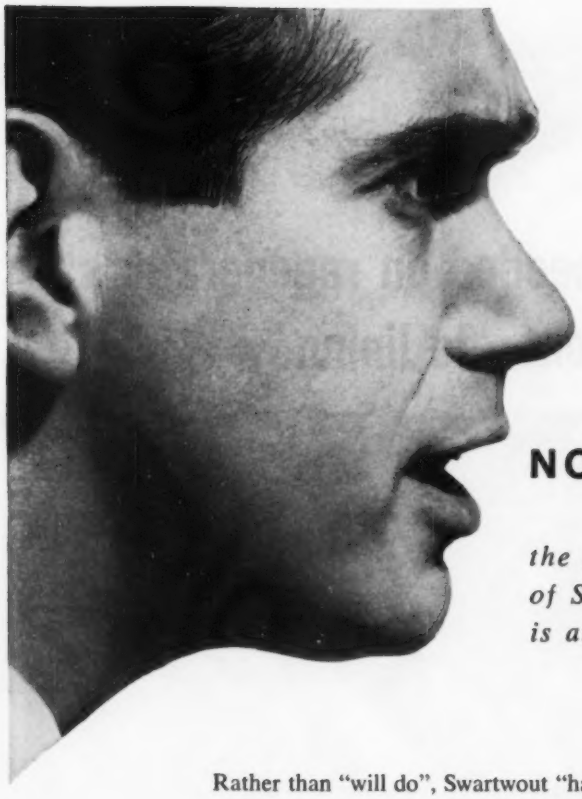
*Stearns-Roger Engineering Company*
*Calgary, Alberta*



# NO PROMISES NEEDED

*the long-term reliability of Swartwout electronic control is an established fact*

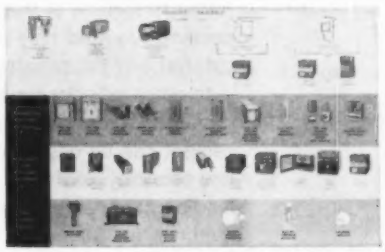
Rather than "will do", Swartwout "has done." No promises—instead, explicit facts based on demonstrated performance. Thousands of electronic control loops (some in service for almost a decade under every conceivable climatic condition) are your assurance when you use Swartwout equipment.

Design philosophy at Swartwout has focused on reliability. The choice of AC for the measuring circuit has permitted use of the simplest and most reliable electrical transmitter ever offered. It has also permitted more stable amplification techniques at the receiving instrument. Now, with the introduction of the new Thermo-Drive valve actuator, highest reliability can be characteristic of the entire loop, sensor through control actuator.

Facts, figures, names and places of installations are most impressive . . . and are available to any instrument user with a practical "show me" approach.

**NEW BULLETIN . . .**
**SHOWS YOU IN PICTURES**

**A new bulletin graphically relates electronic control equipment to practically all process variables. Request Bulletin A-913.**
***Swartwout Division, Crane Co., Hooksett Industrial Park, Manchester, N. H.***



SWARTWOUT
DIVISION
CRANE CO.

**. . . world leader in electronic process instrumentation**

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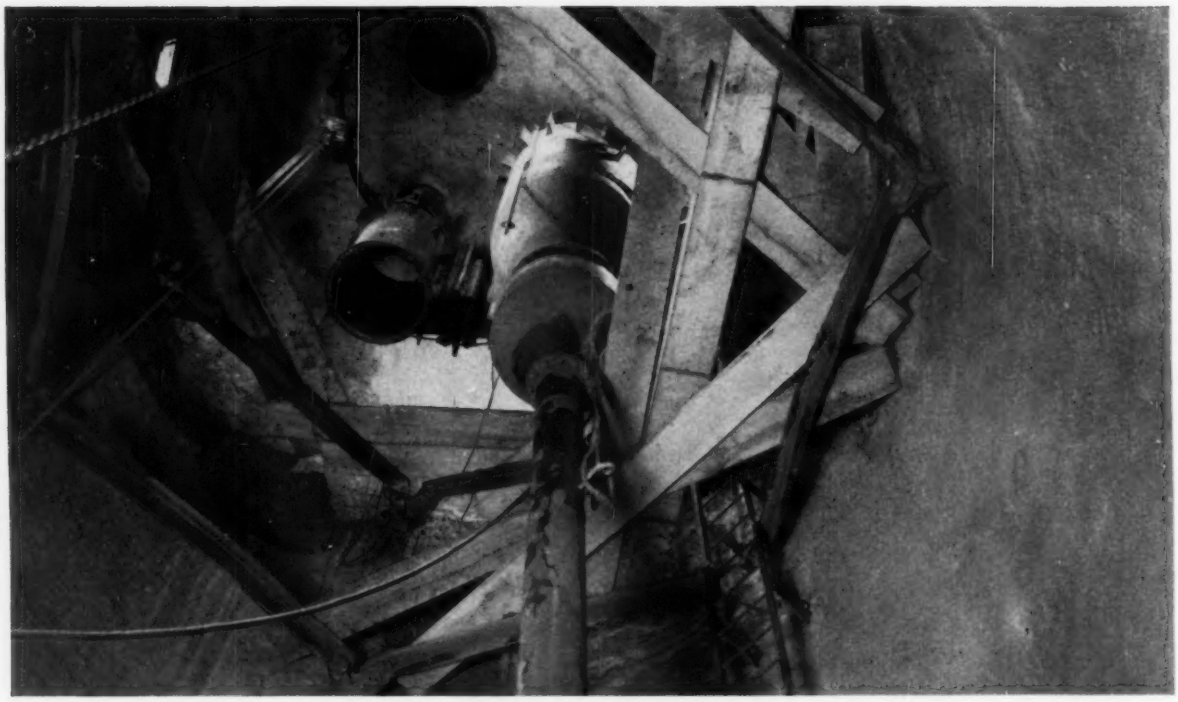
Five years later:

# No repairs needed on regenerator's refractory concrete lining



When this regenerator chamber was opened at the Canton (Ohio) refinery of the Ashland Oil & Refining Company after five years of service, the refractory concrete lining was in excellent condition. No replacement was needed. The smooth, jointless surface of the concrete, made with LUMNITE calcium-aluminate cement, required only minor patching. It resisted abrasion by catalyst and the penetration of gases.

In other refinery equipment (heaters, vapor separators, transfer lines, cyclones, stacks, breechings, etc.) refractory concretes made with LUMNITE cement can be designed to meet every operating condition. For extra convenience and economy, castables containing LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, requiring just water and mixing. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

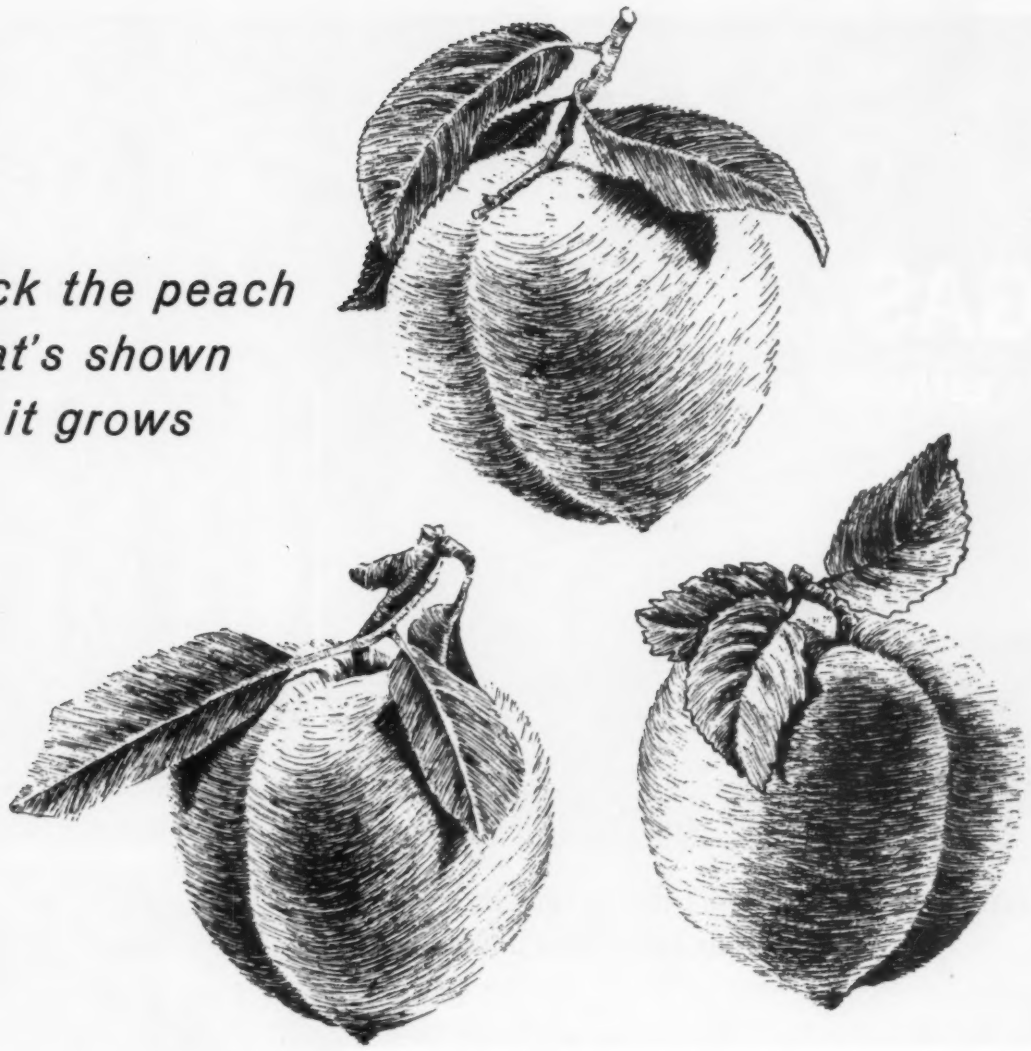
"USS," "Atlas," and "Lumnite" are registered trademarks

L-210

**Universal Atlas Cement**
**Division of**
**United States Steel**

Offices: Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco

*Pick the peach that's shown as it grows*



# Can you tell the real thing when you see it?

It pays to know the fine points . . . in peaches, or products for petroleum processing.

Take liquid caustic. How you get it is almost as important as what you get. Wyandotte can ship caustic to you by barge or ocean tanker, truck or tank car . . . from Geismar, Louisiana (near the mouth of the Mississippi), or from Wyandotte, Michigan (directly accessible to the Great Lakes and the St. Lawrence Seaway). The right choice for you depends on a number of factors. We're familiar with all of them, and would like to help you evaluate them. Call on us.

Wyandotte offers a number of chemicals for the petroleum industry, including materials for drilling muds, gas dehumidification, demulsifying, emulsifying, secondary recovery, water treatment, cementing, sweetening and many other petroleum, refinery, and petrochemical applications. Get full details from your distributor, or write: *Wyandotte Chemicals Corporation, Wyandotte, Michigan. Also Baton Rouge, Louisiana. Offices in principal cities.*

**ANSWER:** You're a pretty sharp picker of peaches if you picked the peach on the top. It's the only one that's paired with a peach leaf. The leaf on the left belongs to an apple, and the one on the right to a pear.

* * * * *

**WYANDOTTE CHEMICALS**

**MICHIGAN ALKALI DIVISION**

*Pacing progress with creative chemistry®*

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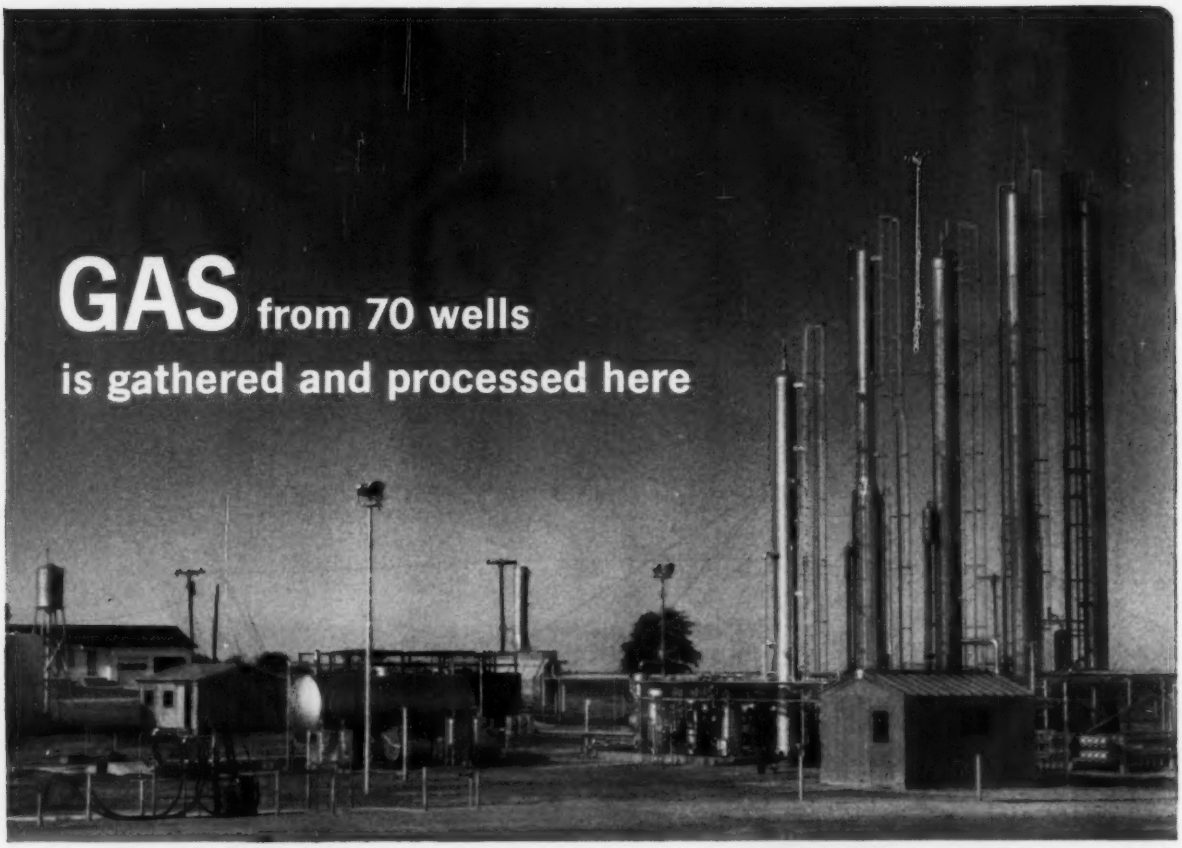



## "JENKINS valves give us the dependable performance our operations demand."

*— states Kerr-McGee Oil Industries, Inc., Oklahoma gas producer*

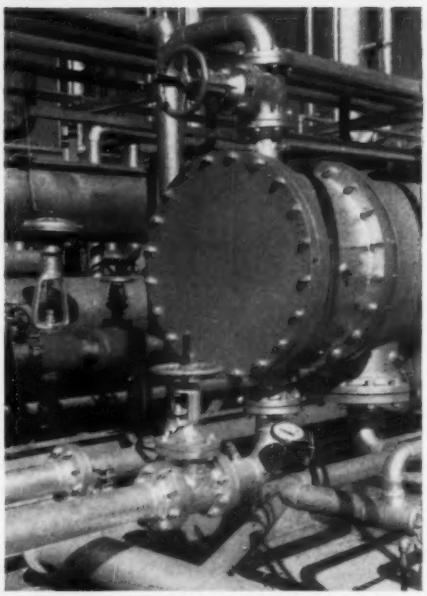
How Kerr-McGee's field processing plant in Lincoln County, Oklahoma, gathers and extracts valuable hydrocarbons from gas before delivering it to the consumer is an interesting story, briefly told below. But you need not know the process to appreciate the fact that maximum reliability in valves is a "must".

The valves that assure Kerr-McGee of dependable, trouble-free performance bear the same name as that written on piping lay-outs of critical jobs of all kinds for almost a century. Experienced engineers, contractors and operating executives know that "JENKINS" stands for an extra-measure of quality. They know it is the best guarantee of long, trouble-free service. There's no extra cost attached to this specification for extra quality, so you can use it for any job. Jenkins Bros., 100 Park Ave., New York 17.

### HOW THE GAS PROCESSING PLANT WORKS...

Because it is a vapor at low pressure, gas is first compressed and injected into the bottom of a tall tower, called an absorber; oil is injected at the top. As the oil goes down, the gas goes up . . . the gas products are absorbed by the oil. The gas enriched oil is then processed to remove valuable light hydrocarbons.

*Sold Through Leading Distributors Everywhere*



Jenkins Gate Valves on lean oil cooler to the absorber

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
JENKINS SINCE 1864 Jenkins Bros

# Valuable blending services available to Du Pont tetraethyl lead customers

When the familiar yellow and green Du Pont tank car rolls onto one of your blending plant sidings, you're taking delivery of more than a shipment of tetraethyl lead—for the services that go with it can be as valuable to you as the antiknock compound is to the quality of your gasolines.

For example, if you're planning continuous in-line blending of gasoline components, Du Pont men are ready to help you with their experience. If you're planning a more modern blending plant, our operations group will be glad to assist your engineers in developing and perfecting its design.

In addition, special services are available for blending plant construction and operation, including, for example, site selection and the training and medical examination of blending plant personnel.

But comprehensive blending plant service is just one example of the many services available to Du Pont tetraethyl lead customers. Your Du Pont Petroleum Chemicals representative will be pleased to discuss them with you. For more information, contact him or write to E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

DU PONT

**Better Things for Better Living**
*. . . through Chemistry*

## Tetraethyl Lead
and other
## Petroleum Additives

# "We deliver too"

What's so special about the huge fractionating tower shown here? It is one more example of how Sun Ship builds and delivers heavy industrial equipment on barges or sea-going vessels, with careful attention to such requirements as safety and on-time schedule.

Whether it's a fractionating tower or key structural part for industry, transporting big items by water or by rail is strictly routine for Sun Ship, for we build and deliver what's needed in many fields. If you have a machinery or heavy equipment problem, write to us about it.

**Sun**

**SHIPBUILDING & DRY DOCK COMPANY**

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.




For more data on advertised products, use Readers' Service Cards, last page.

FALK and STEELFLEX are Registered Trademarks

## Cut disconnect-reconnect time by as much as 50%

The FALK Spacer Coupling is specially designed for quick installation or removal *without disturbing the driving or driven unit.* This feature can save you up to 50% in disconnect-reconnect time when critical equipment—a process pump, for example—needs repair or replacement.

Here's another saving: with the FALK Spacer Coupling, you can quickly realign shafts *without the usual loss of operating temperature!*

And still another: you can remove or reinstall the FALK Spacer as a unit *without draining the lubricant.*

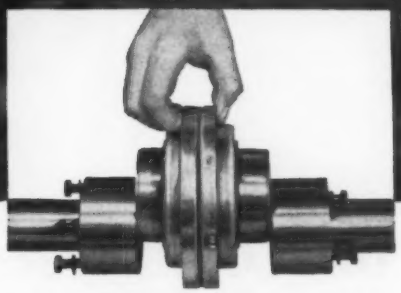
Because of its exclusive grid-groove Steelflex design, the FALK Spacer can accommodate residual misalignment—parallel, angular, or (most important) *both.* Also, it provides torsional resiliency that cushions shock and vibration. Thus it saves wear-and-tear on your connected equipment.

To prove these claims and enjoy these savings, install a FALK Spacer on one application—and see for yourself. Consult your FALK Representative or Authorized Distributor.

**THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN**

*MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS*

**Representatives and Distributors in many principal cities.**

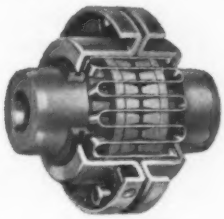


### EASY AND QUICK TO INSTALL, DISCONNECT OR RECONNECT

First, mount shaft hubs to allow proper distance between hubs; then, align driving and driven units.

Second, compress Spacer to fit space between hubs and tighten cap screws to pull spacer hubs into the registered fit.

To disconnect, reverse the second step. No draining of lubricant necessary.



**The heart of the FALK Spacer ...the basic Type F Steelflex**

*Write for Service Manual 4838*

**FALK**

...a good name in industry

**. . . in fluid catalytic cracking**

# DUCLONES® recover catalyst in world's leading refineries

Control of catalyst dust in reactors and regenerators of fluid catalytic cracking units is essential from the standpoints of operating efficiency, economy and air pollution control.

Type SDC Duclones and Ducon Dip-Leg Trickle Valves offer the ultimate in catalyst recovery systems. They have earned the enthusiastic approval of the world's leading refineries because of their consistently high efficiency, low pressure loss and long service life under high temperature and erosive conditions. Type SDC Duclones are available in a wide range of materials, sizes, plate thicknesses and multiple groupings. They can also be supplied lined with a refractory material.

*Send today for Bulletins C-2058 and V-1458.*

*Photo courtesy Tidewater Oil Co.*

DUCON — DUST CONTROL SYSTEMS AND EQUIPMENT

**the name in DUst CONtrol**

**THE Ducon COMPANY INC.**
**147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK**

**Canadian Branch:**
**THE DUCON COMPANY of CANADA, Ltd.,**
**1131 Pettit St., BURLINGTON, ONTARIO**

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

ANOTHER **Vogt FIRST**

## 9 NEW FLANGED END FORGED STEEL

GENERAL GP PURPOSE

## Gate, Globe and Check VALVES

*with*

**HARD FACED SEATS**
150, 300 and 600 ASA STANDARD

*featuring:*

ASA Standard flanges and face-to-face dimensions
*Stellite hard faced seats and hardened wedges and discs
Spiral wound body-bonnet gaskets
Stainless steel gland studs and nuts
Interchangeable parts
Light weight with maximum strength
Complete line—pressures, sizes and types

*Union Carbide Corp.

*Write for Literature. Address Dept. 244-FPR.*

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**FORGED STEEL VALVES**




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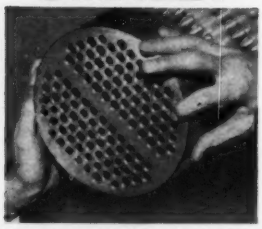
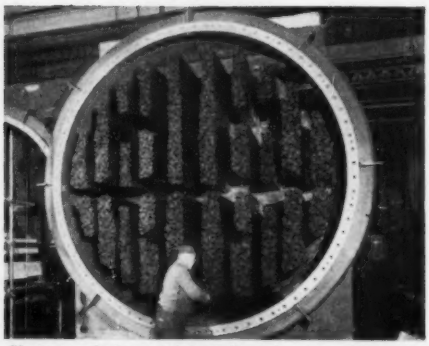
## SMALL!



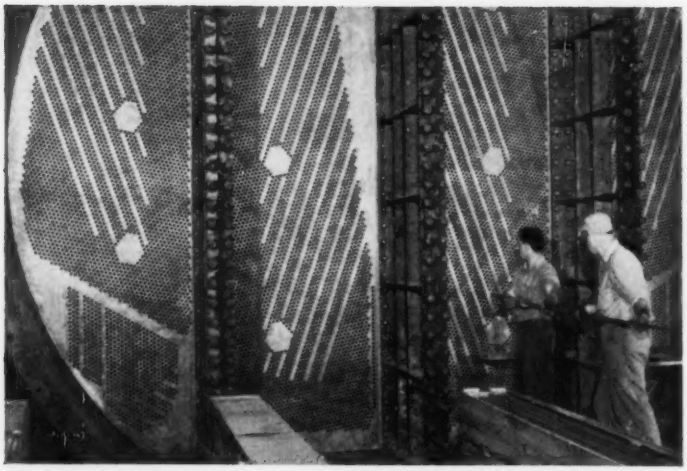
Small tubes like these for oil heaters and coolers are precision-made, give unexcelled service.

## BIG!



Chase regularly supplies quality tubes in a wide range of alloys to fabricators of units such as this 25,000 sq. ft. condenser, shown here under construction.

# BIGGEST!



Cycles of retubing vast public utility condensers using around 100 tons of tubes are far less frequent when long-lasting Chase tubes are selected.

## Chase Heat Exchanger Tube Service Is Complete!

Need a dozen small tubes in a hurry for a replacement job—Or 100 TONS for a new installation? Chase is geared to give you the best possible service in either case. Warehouse and mill stocks enable us to meet emergency schedules. Mill facilities are geared to turn out big orders quickly.

Chase offers one of the most complete selections of condenser and heat exchanger tube alloys to meet any condition, and in a wide range of sizes. We can supply U-Bends, tubes with thickened centers or thickened ends, bi-metal, etc.

Call or write the nearest Chase Warehouse or Chase Sales representative.

Chase® BRASS & COPPER CO. WATERBURY 20, CONN.
Subsidiary of *Kennecott Copper Corporation*

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY BRASS & COPPER

THE NATION'S HEADQUARTERS FOR **ALUMINUM • BRASS • BRONZE • COPPER • STAINLESS STEEL AND FORGINGS**

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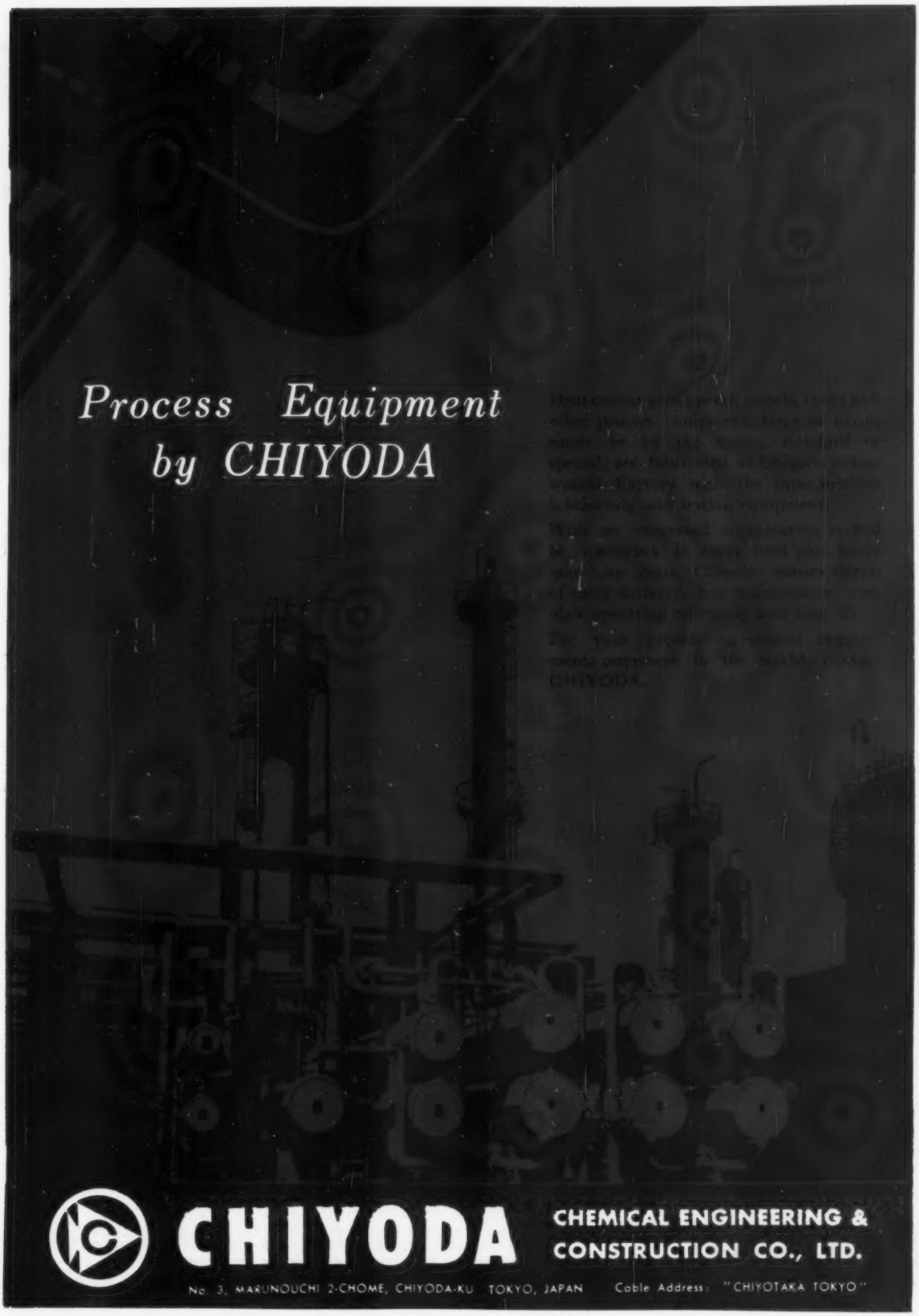





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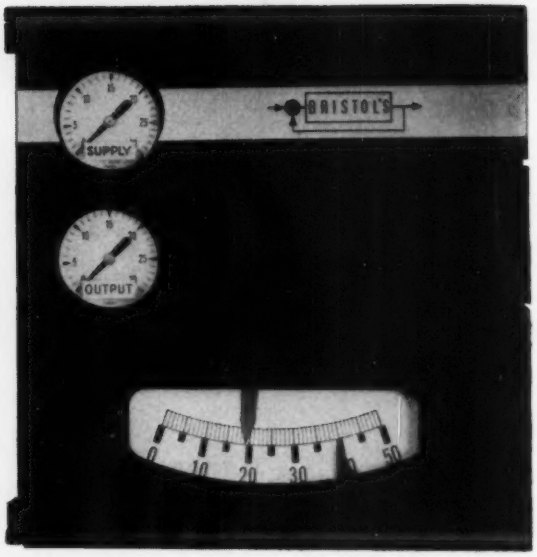
NEW

BRISTOL'S




# Series 624 A/D* pneumatic controller features simplicity and high control stability

- **Simple modular design for ease of servicing**
- **High control stability for closer process control**
- **Designed for batch-type and continuous processes**
- **Proportional and proportional-plus-reset control models available**

Top control performance with maximum simplicity plus standard Bristol precision measuring elements—those are the key features of the Bristol Series 624 Controller. The 624 uses the same renowned elements that have earned such a reputation for accuracy and dependability on other Bristol automatic controlling and recording instruments—perfected through wide experience and many years of development.

Self-contained modular design of the control unit speeds servicing. The whole modular unit, consisting of an aluminum casting with working parts made of stainless steel, Ni-Span C, and Neoprene diaphragms, can be removed by taking out only two screws and a link.

Outstandingly compact, the aluminum instrument case (only 8" x 8" x 5" overall) is completely weatherproof. It is designed for either flush, surface, panel, or valve mounting. Attachments for pipe mounting (2-inch pipe) are available. Write for complete data on the versatile and economical 624 A/D. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. 0.35

*Advanced Design*

**CONTROLLERS OFFERED FOR:**

**PRESSURE AND VACUUM:** Ranges from full vacuum to 10,000 psi.

**TEMPERATURE:** Ranges from —100°F to +1000°F.

**FLOW AND DIFFERENTIAL PRESSURE:** With mercury-type manometer and dry-type differential unit.

**LIQUID LEVEL:** With bulb unit and mercury manometer and dry-type differential unit.

**HUMIDITY:** Zero to 100% relative humidity.

**CONTROL UNIT CHARACTERISTICS:**

**PROPORTIONAL BAND:** 0-400% continuously adjustable, direct- or reverse-acting.

**RESET:** 0.1 to 50 repeats per minute.

**AIR PILOT:** Non-bleed type.

**PILOT CAPACITY:** 4.0 scfm.

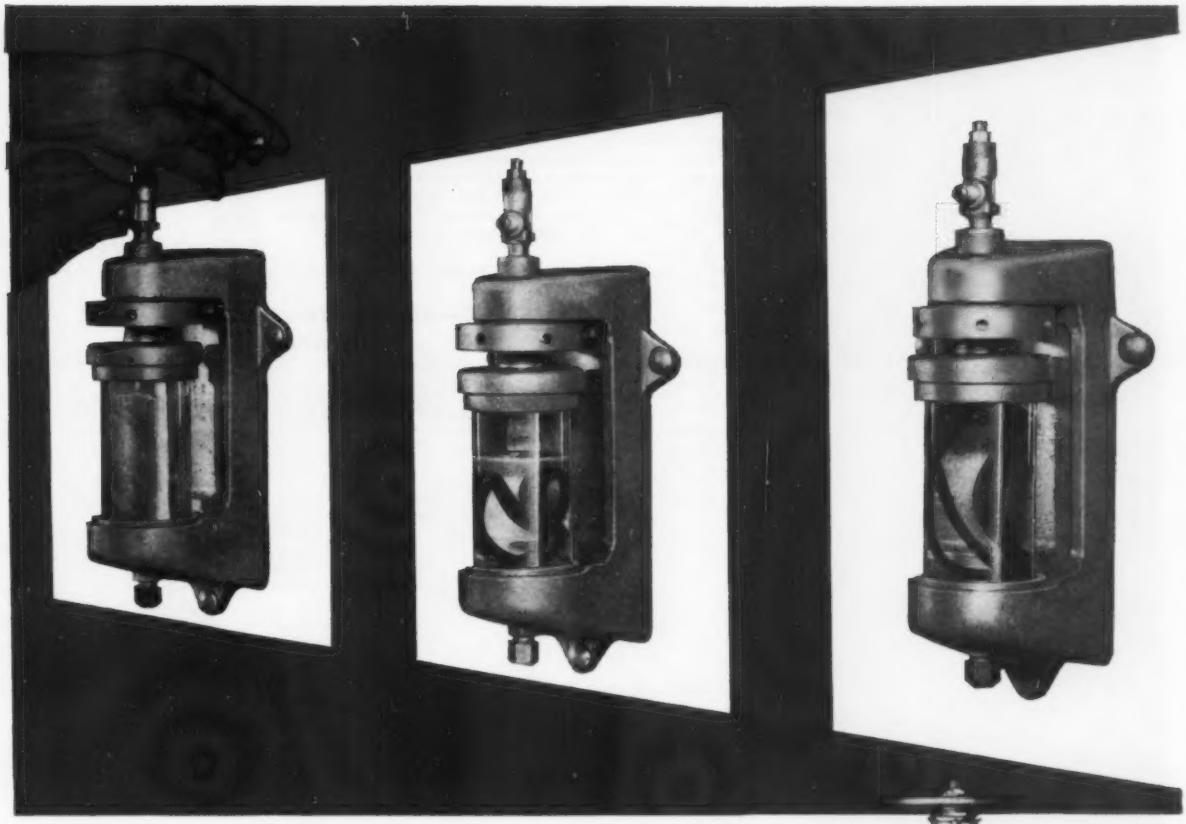
**FREQUENCY RESPONSE:** Flat to 400 cycles per minute.

**TEMPERATURE STABILITY:** Less than 0.1% change in the output pressure for 90°F temperature change.

**MATERIAL:** Aluminum housing; 316 stainless steel internal parts; Ni-Span C feedback element.

**BRISTOL**... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



# Kerotest Valve Parts Get the ALL CLEAR FROM BOMBS

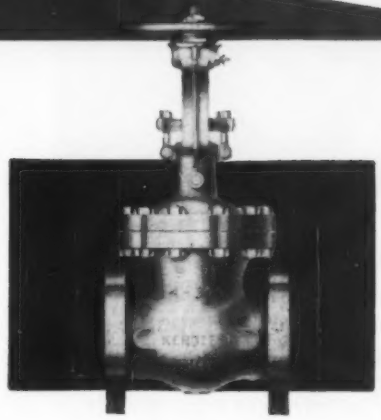
All materials and parts that go into Kerotest Valves must first get the all clear in these pressurized material test bombs at the Kerotest laboratories. Packings, plastics, gaskets, O-rings, seat rings, steel, and other materials are accepted as suitable only after they've withstood the deteriorating effects of various gases, vapors, liquids and refrigerants for specified test periods.

Kerotest quality controls are applied from the initial development and engineering phase to the final assembled valve. For those who specify and use Kerotest Valves these high standards of material and production quality mean greater valve value per dollar. With Kerotest there's minimum risk of valve failure in service and improved operating efficiency with less maintenance.

**Kerotest Cast Steel Gate Valves**

High quality Kerotest cast steel gate valves are available in primary service pressure ratings ranging from Series 150 to Series 1500. They are supplied in various combinations of body and trim material for all types of service in oil, gas, steam, water, chemical, petro-chemical, marine and industrial installations.

*Send for your free copy of the new, informative Kerotest booklet. It's packed with working tables, dimensions, specifications and other helpful information.*



**KEROTEST**
**Quality Controlled Features**

- Reinforced wall sections guard against unusual strains — erosion and corrosion.
- Built for repacking under pressure in the full open position.
- Deep stuffing box for greater packing life and tighter seal.
- Threaded, bottom seating type seat rings. Made without protruding lugs to permit full clear way opening through valves.
- All yokes made to withstand rough handling and equipped with lubrication fitting to stem nut.

**There is a Kerotest Cast Steel Valve available for every class and condition of service.**

## KEROTEST MANUFACTURING COMPANY

**2514 LIBERTY AVENUE • PITTSBURGH 22, PA.**

In Canada... Kerotest Cast Steel Valves are manufactured and distributed exclusively by Guelph Engineering Company, Guelph, Ontario, Canada

KEROTEST®



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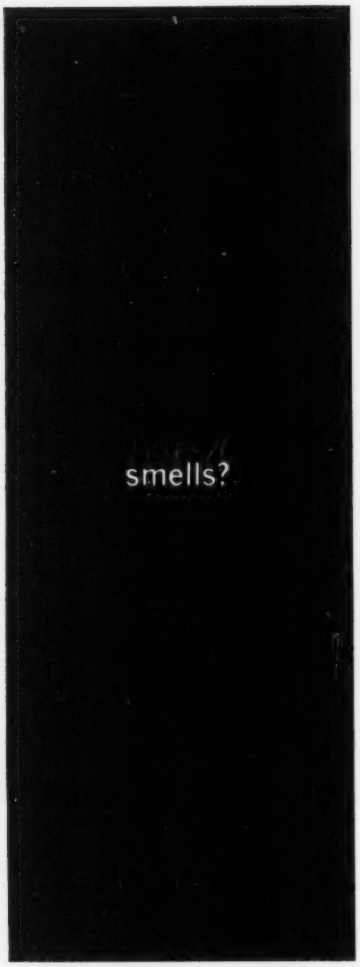


**Call on Rhodia "Odor Engineering" to solve your malodor problems in plant or product**

Rhodia Inc. is the world leader in industrial odor control and reodorization technology and a primary producer of industrial aromatic chemicals. It offers fully qualified consultation service anywhere in the United States without cost or obligation.

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Please send me Rhodia literature.
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60 East 56 St., New York 22, New York
(Phone: PLaza 3-4850)


# The Mail Box...

## Tables Are Corrected

To the Editor:

In making some thermodynamic calculations involving gaseous 1,2-dichloroethane (EDC), the values of $\Delta H_f$ and $\Delta G_f$ given by Kobe and Crawford, PETROLEUM REFINER, **37**, No. 7, 125 (1958), were found to be in error.

One of the errors made was to mistake the $\Delta H_f$ and $\Delta G_f$ of liquid EDC for that of the gas. Also some of error has been made in their calculation of temperature dependence.

Edward Bollinger
The B. F. Goodrich Company
Brecksville, Ohio

## Author's Reply

I wish to thank Messrs. Edward Bol-

**TABLE 3—Heats of Formation**

$\Delta H_f°$ in kcal/g-mole

| T, °K | Nitrous Oxide $N_2O$ | Isopropyl Alcohol $C_3H_7OH$ | Methylene Chloride $CH_2Cl_2$ | Chloroform $CHCl_3$ | 1, 2-Dichloroethane $C_2H_4Cl_2$ |
|---|---|---|---|---|---|
| 273.16 | 19.29 | —65.01 | —20.88 | —23.95 | —31.05 |
| 291.16 | 19.43 | —65.29 | —20.97 | —23.99 | —31.18 |
| 298.16 | 19.49 | —65.40 | —21.00 | —24.00 | —31.23 |
| 300 | 19.50 | —65.43 | —21.01 | —24.00 | —31.24 |
| 400 | 20.37 | —66.81 | —21.42 | —24.16 | —31.89 |
| 500 | 21.30 | —67.92 | —21.75 | —24.26 | —32.43 |
| 600 | 22.29 | —68.79 | —22.00 | —24.30 | —32.88 |
| 700 | 23.31 | —69.46 | —22.19 | —24.31 | —33.23 |
| 800 | 24.35 | —69.95 | —22.33 | —24.29 | —33.48 |
| 900 | 25.41 | —70.27 | —22.42 | —24.25 | —33.66 |
| 1000 | 26.48 | —70.47 | —22.47 | —24.19 | —33.76 |
| 1100 | 27.56 | —70.55 | —22.50 | —24.12 | —33.80 |
| 1200 | 28.64 | —70.54 | —22.50 | —24.04 | —33.78 |
| 1300 | 29.72 | —70.46 | —22.49 | —23.96 | —33.73 |
| 1400 | 30.80 | —70.33 | —22.46 | —23.87 | —33.64 |
| 1500 | 31.89 | —70.16 | —22.42 | —23.78 | —33.55 |

**TABLE 4—Free Energies of Formation**

$\Delta G_f°$ in kcal/g-mole

| T, °K | Nitrous Oxide $N_2O$ | Isopropyl Alcohol $C_3H_7OH$ | Methylene Chloride $CH_2Cl_2$ | Chloroform $CHCl_3$ | 1, 2-Dichloroethane $C_2H_4Cl_2$ |
|---|---|---|---|---|---|
| 273.16 | 24.31 | —43.73 | —14.58 | —16.67 | —19.14 |
| 291.16 | 24.63 | —42.31 | —14.17 | —16.18 | —18.36 |
| 298.16 | 24.76 | —41.76 | —14.00 | —16.00 | —18.05 |
| 300 | 24.79 | —41.61 | —13.95 | —15.95 | —17.96 |
| 400 | 26.43 | —33.46 | —11.54 | —13.24 | —13.44 |
| 500 | 27.83 | —24.99 | — 9.03 | —10.50 | — 8.76 |
| 600 | 29.05 | —16.32 | — 6.46 | — 7.74 | — 3.98 |
| 700 | 30.09 | — 7.52 | — 3.86 | — 4.98 | 0.86 |
| 800 | 30.99 | 1.37 | — 1.23 | — 2.23 | 5.75 |
| 900 | 31.76 | 10.30 | 1.42 | 0.53 | 10.60 |
| 1000 | 32.40 | 19.27 | 4.06 | 3.28 | 15.60 |
| 1100 | 32.94 | 28.24 | 6.72 | 6.03 | 20.54 |
| 1200 | 33.39 | 37.22 | 9.38 | 8.77 | 25.47 |
| 1300 | 33.74 | 46.20 | 12.03 | 11.49 | 30.41 |
| 1400 | 34.01 | 55.17 | 14.69 | 14.22 | 35.33 |
| 1500 | 34.20 | 64.13 | 17.34 | 16.94 | 40.26 |

**TABLE 5—Logarithm of Equilibrium Constant of Formation**

$\log_{10} K_f$

| T, °K | Nitrous Oxide $N_2O$ | Isopropyl Alcohol $C_3H_7OH$ | Methylene Chloride $CH_2Cl_2$ | Chloroform $CHCl_3$ | 1, 2-Dichloroethane $C_2H_4Cl_2$ |
|---|---|---|---|---|---|
| 273.16 | —19.450 | 34.988 | 11.665 | 13.338 | 15.314 |
| 291.16 | —18.487 | 31.758 | 10.636 | 12.145 | 13.781 |
| 298.16 | —18.149 | 30.610 | 10.262 | 11.728 | 13.231 |
| 300 | —18.06 | 30.313 | 10.163 | 11.620 | 13.084 |
| 400 | —14.440 | 18.281 | 6.305 | 7.234 | 7.343 |
| 500 | —12.164 | 10.923 | 3.947 | 4.589 | 3.829 |
| 600 | —10.581 | 5.944 | 2.353 | 2.819 | 1.450 |
| 700 | — 9.394 | 2.348 | 1.205 | 1.555 | — 0.268 |
| 800 | — 8.466 | — 0.374 | 0.336 | 0.609 | — 1.571 |
| 900 | — 7.712 | — 2.501 | — 0.345 | — 0.129 | — 2.574 |
| 1000 | — 7.081 | — 4.211 | — 0.887 | — 0.717 | — 3.409 |
| 1100 | — 6.545 | — 5.611 | — 1.335 | — 1.198 | — 4.081 |
| 1200 | — 6.081 | — 6.779 | — 1.708 | — 1.597 | — 4.639 |
| 1300 | — 5.672 | — 7.767 | — 2.022 | — 1.932 | — 5.112 |
| 1400 | — 5.309 | — 8.612 | — 2.293 | — 2.220 | — 5.515 |
| 1500 | — 4.983 | — 9.344 | — 2.526 | — 2.468 | — 5.866 |


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*as described in U.S. Patent 2,389,608.

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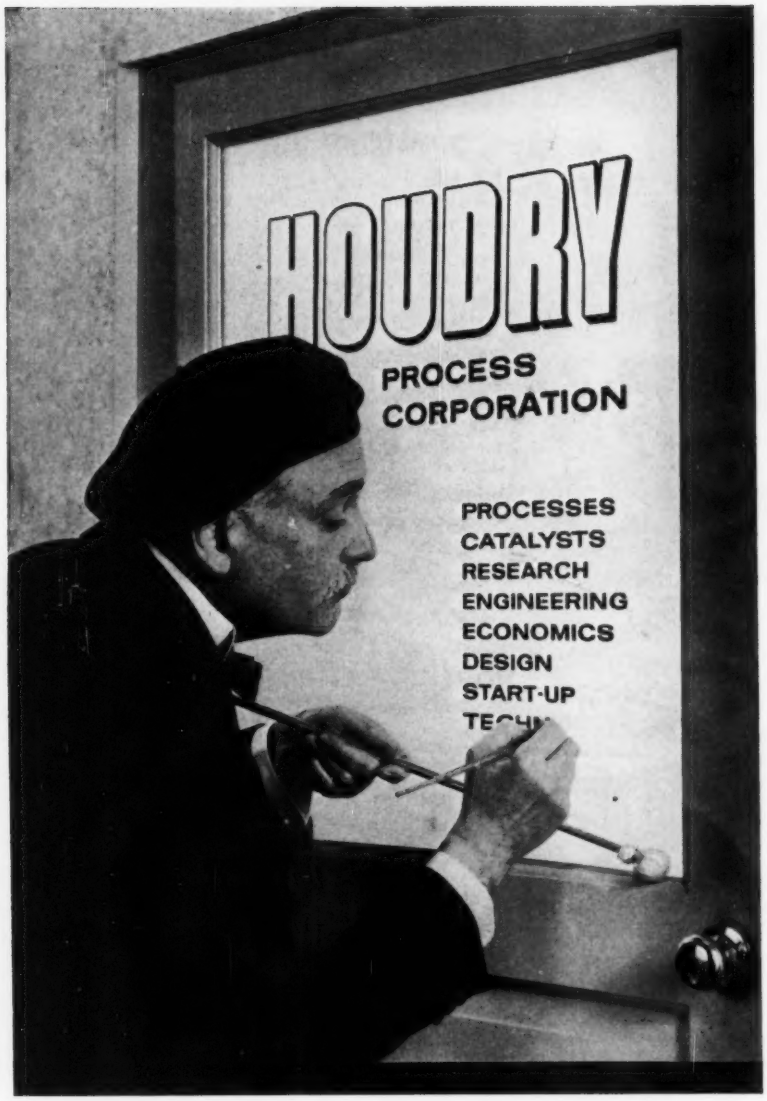


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## *Letters . . .*

linger, H. J. Vogt, Jean Dumoulin and others for pointing out some of these errors and especially to Mr. Donald Flanagan who helped make the corrections.

Equation (23) should read

$$\Delta S_f^\circ = I_s + \Delta a \ln T + \Delta b T + \frac{\Delta C}{2} T^2 + \frac{\Delta d}{3} T^3$$

Errors were made for nitrous oxide, isopropyl alcohol, methylene chloride, chloroform, and 1,2-dichloroethane. Corrections for these compounds for tables 3, 4, and 5 are shown herewith.

H. R. Crawford

Dallas, Texas

### "Not" Didn't Belong

The June Mail Box contained a letter by James H. Lovell, Jr., Kaiser Aluminum, Oakland, Calif., referring to a How To Do It item on sheathing originally published in our February 1960 issue. Mr. Lovell was quoted as follows: "We do not feel however, that we should assist where indicated in assuring the accuracy of published data on aluminum." If the "not" in the sentence were omitted, Mr. Lovell would have been quoted correctly.

### Start Near Top

To The Editor:

I read the article, "How Professional Is Your Management" in your February issue with a great deal of interest and approval.

It seems to me that as soon as engineers become chief engineers, managers or officers of large corporations, they forget their professional obligations to the engineers under them. They then get big, well furnished offices and a private secretary to do their work while keeping two or three experienced engineers together in small, poorly equipped offices and frequently having one stenographer, usually freshly out of high school for comon use by six or seven engineers. This treatment kills the professional pride of the engineers and makes them feel that they don't amount to much. It takes a lot of ego and initiative for a young engineer to go ahead and make something of himself in spite of this humiliating treatment. I doubt if many of the large corporations in the oil business would pass your test. I hope that many engineers fill out your form and send it directly to top management in their companies.

I think that when engineers are promoted to positions of responsibility, their attitude toward their engineering employes should be watched by the engineering societies and that they should be advised of any shortcomings. There should be some kind of disowning of those who neglect the professional standing of their engineers. Of course nothing of this kind can come from engineers within industry unless from near the top of management for the others are naturally afraid of advocating such measures. I do not believe most of these managerial engineers actually realize their unprofessional attitudes.

Forrest E. Gilmore

Independence, Kans.



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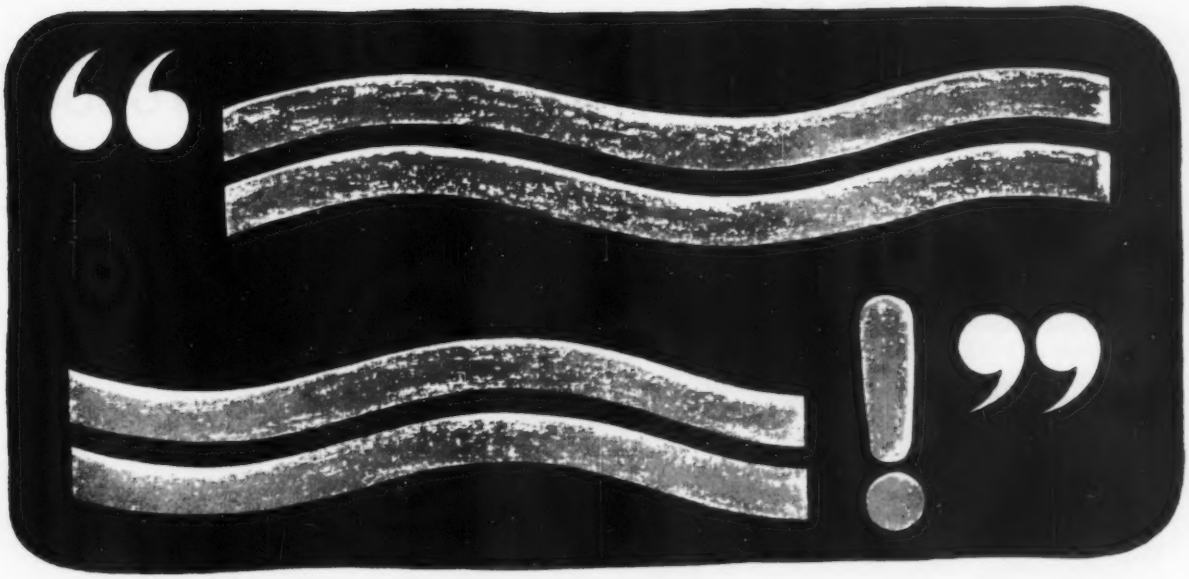

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For data on Clark Centrifugal Compressors and Reciprocating Compressors consult your nearest Clark representative or write for Bulletin 175 on Isotemp Compressors, Bulletin 150 on Centrifugal Oxygen Compressors or Bulletin 160 on Clark Reciprocating Process Compressors.

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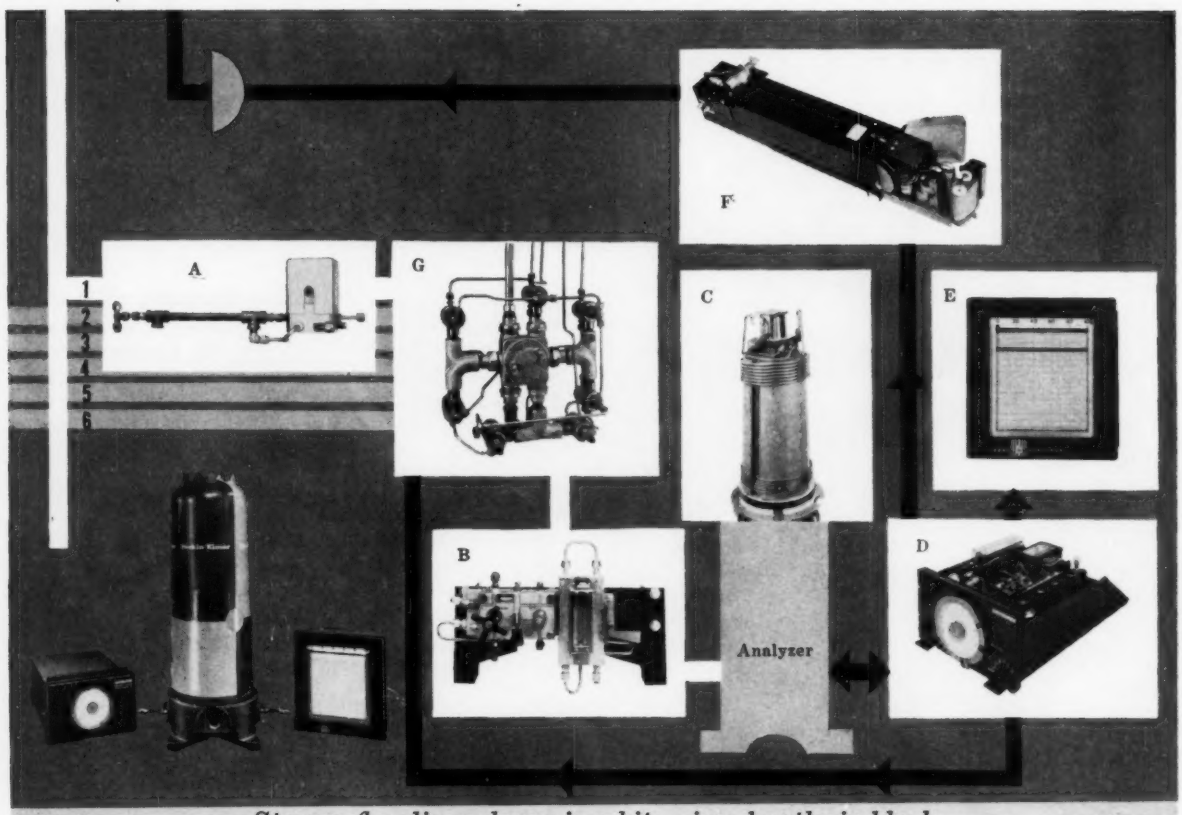


*Stream flow lines shown in white, signal paths in black*

This block diagram shows how six process streams can be selectively analyzed by the P-E Model 184-B. For brevity, Stream #1 only will be followed through the system.

Stream #1 is tapped, and the sample vaporized in the Liquid Sample Vaporizer (A). Sample #1 then flows (with the other five vaporized samples) into the enclosed, heated Multi-Stream Solenoid Switching Manifold (G). The solenoids are electrically directed by the Programmer (D). As it is selected, Sample #1 is valved into the Final Sampling Assembly (B), where it is filtered and metered into the Analyzer. The Analyzer quantitatively and qualitatively separates the sample's components by gas chromatography, produces signals which appear as a bar graph on Recorder (E).

The signal can also be fed into a Pneumatic Control Accessory (F) which produces a 15 psi signal for automatic control of one variable component of the stream.

The Analyzer with Reverse Flow Valve (C) allows for the analysis of light components individually plus a "total heavies" measurement; it back-flushes and analyzes heavy ends as a single peak, shortening analysis time in the process. The Programmer (D) is available in a variety of modes for multi-component and multi-stream analysis. It controls the Switching Manifold (G) and the Analyzer, and the read-out of the Recorder (E).

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# Unusual foundation design for . . . TALL TOWERS

**Close centerline distance, high towers, weak clay soil and hurricane winds gave Phillips some interesting problems**

**Edward V. French**
Phillips Petroleum Company, Bartlesville, Okla.

SEVERAL UNUSUAL conditions faced Phillips' engineers in the design of a common foundation for two tall fractionating towers. The towers were to be located in the Phillips' refinery near Sweeny, Texas.

The design conditions presented these difficult problems:

- The towers were fairly high and close to one another.
- The soil consisted of a relatively weak clay.
- Horizontal forces were to be based on hurricane winds and aerodynamic vibrations.
- Each tower had to be structurally independent of the other and each self supporting.

**Layout Study.** A study of proposed layouts indicated that it was economically advantageous from a piping viewpoint, to space the towers close to one another. An investigation showed that for independent foundations,

**FIGURE 1—Gin pole supports tower as it is raised free of ground.**

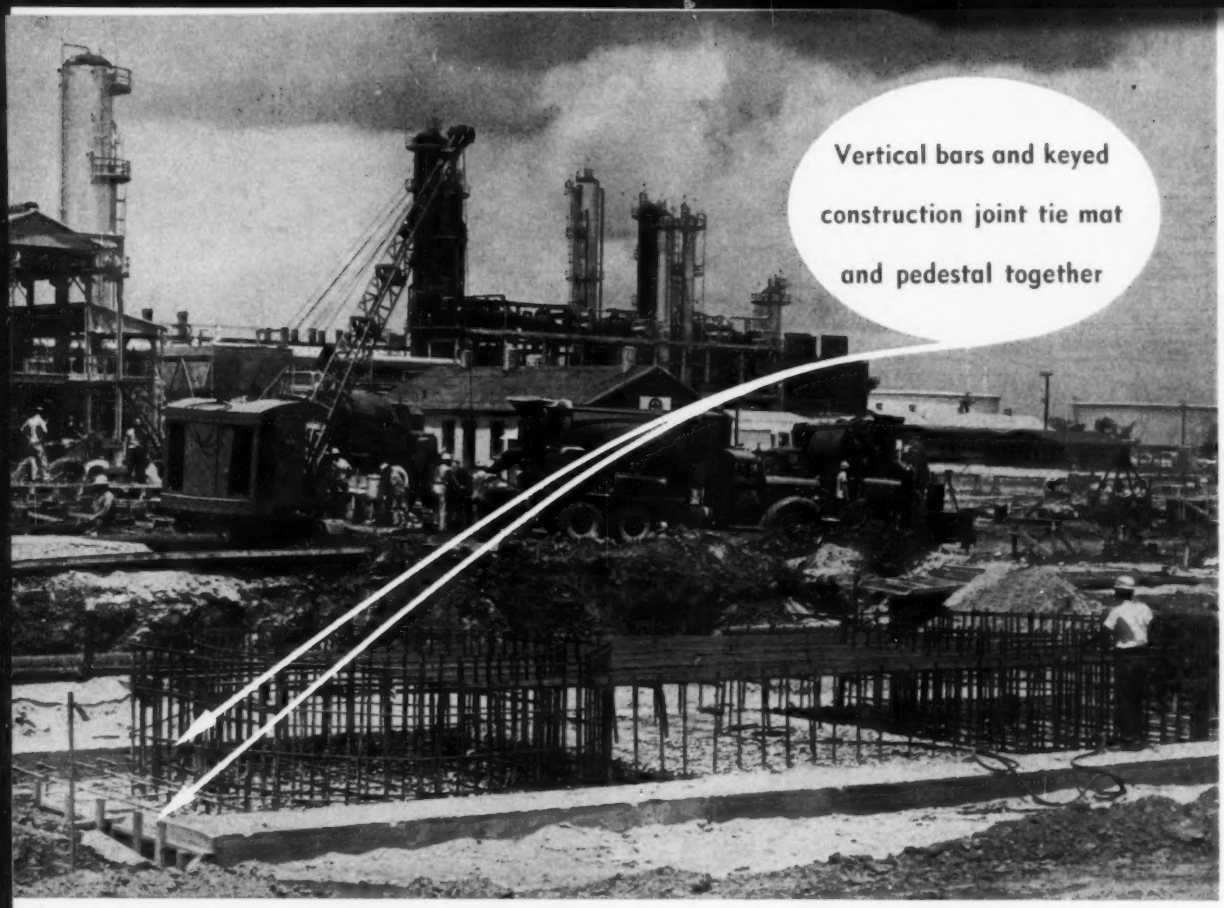


**FIGURE 2—This is the foundation after the first pour.**

octagonal mats at least 40 feet in diameter would be required and that any spacing of about 40 feet or less would involve a combined foundation.

Although this investigation indicated that there would be no appreciable economy in materials using a combined foundation, one advantage was apparent although somewhat unmeasurable. It is possible that the towers may vibrate when subjected to steady winds of 35 to 55 mph velocity. A natural vibration period of 1.0 second per cycle was calculated for the shorter tower and 1.4 second per cycle for the taller one. Assuming aerodynamic vibrations to occur at these frequencies, impulses transmitted by either tower into a common foundation would tend to be damped by the effect of the unlike opposite tower. This damping would be effective to some degree whether one or both towers were in motion or regardless of wind direction.

In view of these factors, it was planned to space the towers on 28 foot centers using a common foundation. This spacing allowed adequate clearance for erection and maintenance operations. A plan and elevation view showing the arrangement and general details is shown in Figure 3.

**Soil Conditions.** The soil at the foundation site is cohesive. Borings were made and laboratory tests run of the soil samples. A 5-foot top stratum consists of black and tan organic clay. This is underlain with 2 feet of stiff tan inorganic clay below which lies clayey sand and sand. Using shear strengths indicated by the tests and Terzaghi's bearing capacity equation, the allowable soil pressure of 4,000 psf was determined. This was based on a safety factor of 2 at a 7-foot depth with no increase permitted when combining wind and vertical loads. After the mat had been sized, uniform soil pressure due to vertical loads totaled only 1,500 psf. Computed total settlement was consequently small and a major percentage of it could be expected to occur during construction.

**Load Combinations.** The effects of three separate combinations of vertical and wind loads from the towers were investigated:

**1.** Vessels ready for operation plus full wind forces but without operating liquids.

**2.** Vessels operating plus full wind forces.

**3.** Vessels ready for operation under water test conditions without wind.

**Tower Fabrication.** Schedules controlling tower fabrication and tray delivery were coordinated so that the trays could be shop-installed. Also, platforms, ladders and most piping were scheduled for installation immediately after the towers were to be erected. In addition, backfill material was to be placed before the towers were

erected. Since the likelihood was remote that both towers would be left stripped down for an appreciable time, no "erection" condition was considered other than to check for stability.

Wind forces were computed on the basis of 125 mph maximum gust velocity at a 30 foot height. Height factors were then applied which gave the following pressures in three height zones:

| | | |
|---|---|---|
| 0- 50 feet | 52 | psf |
| 51-100 feet | 62 | psf |
| Above 100 feet | 72.2 | psf |

These values represent pressure against flat surfaces. A shape factor of 0.6 was applied to compute the pressure against projected areas of cylindrical surfaces.

**Anchor Bolts.** In designing anchor bolts, the upper pedestals were analyzed as cantilevered flexural members, loaded with combined bending and axial forces. Compressive stress in the concrete and tensile stress in the anchor bolts was then calculated according to the theory of flexure for concrete. Both carbon and alloy steel were considered for bolt material, but investigation showed that an alloy steel with higher allowable stresses and less tendency to creep under load was the most desirable. The practical limit on the number of bolts that could be placed around either tower perimeter was approximately 36. This in effect established the total tension force which each bolt must resist. Maximum bolt diameter was not a limiting factor, but by using the higher allowable stress of alloy steel a substantially smaller bolt could be used. This was advantageous from a handling and installation viewpoint. Since some degree of aerodynamic vibration of the towers is possible, it was considered imperative that all anchor bolts be pretensioned and that under sustained loading; elongation be held to a minimum. For each tower, 36 one-piece bolts, projecting 2 feet above the concrete, were equally spaced around the vessel perimeter. All bolts were threaded on each end and anchored mechanically at the bottom with a 2½-inch thick rectangular plate held between two torqued nuts.

**Octagon Pedestal.** Because vertical loads for both towers were considered equal they were centered symmetrically about the foundation centerline. The condition causing the greatest eccentric loading from vertical forces alone would result from either tower being water tested singularly. This eccentricity, found to be considerably less than that caused by maximum wind forces, was not critical. The combined wind overturning moment from both towers applied at the top of foundation was 27,750 foot kips. Any wind shielding effect by either tower was neglected and the overturning moment was assumed equal in all directions. Because of this, an octagonal outline for the foundation mat was more suitable for limited soil pressure than was a square or rectangular shape.

Using a maximum toe pressure of 4,000 psf, a 50-foot diameter octagon was found to satisfy all load combinations, with the number 2 load combination actually controlling the diameter. The weight of the operating liquids was relaively small when compared with the total mass and overturning moment. As a result, there was less than 10 percent difference in the toe pressure and/or

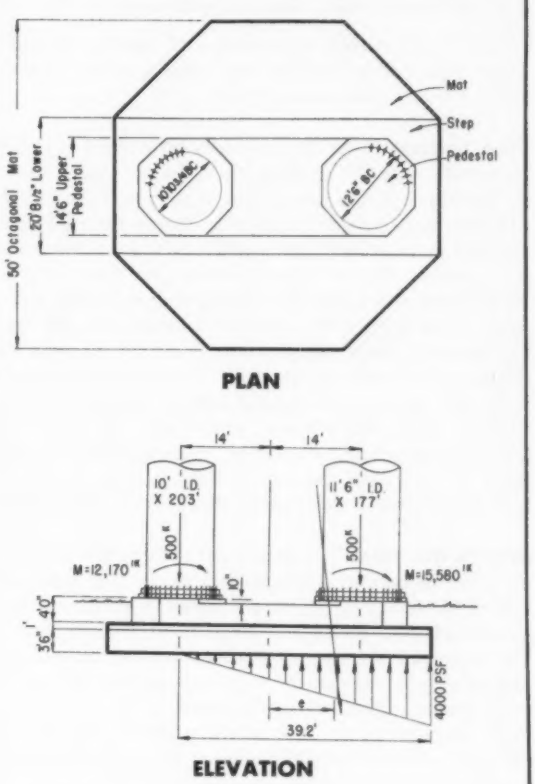


**FIGURE 3—Plan and elevation showing towers spaced at 28 feet on centers.**

## DESIGN CONDITIONS

**One tower is 11½ feet in diameter by 177 feet in height. The other is 10 feet in diameter and 203 feet high. Although the towers differed considerably in size, there was less than 3 percent difference in the calculated vertical loads for each. This was found to be true for both operating and empty conditions. For design purposes, vertical loads for each tower were considered equal. Empty tower weights included the vessels plus all accessories ready for operation. Operating weights consisted of empty tower weights plus operating liquid. Other data and conditions which governed foundation design are as follows:**

**Tower weight, empty, each 425 kips.**

**Tower weight, operating, each 500 kips.**

**Maximum velocity of wind, 125 mph.**

**Maximum allowable soil pressure, 4,000 psf.**

**Maximum settlement allowed, ½ inch.**

**Minimum stability ratio, 1.5.**

**Concrete—3,000 psi in 28 days. Where applicable ACI Code (318-56) to govern design and detailing. $f_c$ and $f_s$ to be increased by one-third where stresses are due to combined wind and vertical load.**

**Maximum allowable anchor bolt stress:**

**Alloy steel, 40,000 psi.**

**Carbon steel, 20,000 psi.**

eccentricity between operating and empty conditions. The stability factor under load combination 1 was 2.4, and for load combination 2, 2.6.

**Step Section.** After the mat had been sized it was determined, by trial and error calculations, that a stepped section through the center was desirable. This step was run continuously one foot thick, across the mat center and for convenience was made equal in width to the octagon side. At the edge of the step, the mat depth was set at three and a half feet which with sufficient bottom steel would approach a balanced design for the resisting moment from soil pressure. This depth was then continued to the outer edges of the mat in order to minimize the steel requirements and to maintain over-all stiffness. The pedestals were then made equal in width for symmetry and connected. A minimum allowable cover of 12 inches, outside of anchor bolts on the 11-foot, 6-inch tower, determined the 14-foot, 6-inch width.

**Mat Reinforcing.** The mat reinforcing in the transverse direction or perpendicular to face of the step was determined by analyzing sections across the entire width of the foundation. Shear and moment at sections through the center, at the face of pedestal, at the face of step, and at points between the step and outside edge of mat were computed. Load combination 2 caused a maximum moment at the face of the pedestal and step and at other points toward the edge of mat. Maximum moment in the same direction through the foundation centerline was caused by load combination 3. To satisfy this shear and moment, eighty-one #11 bars were spaced on six inch centers in the bottom of the mat at the face of the pedestal and step, forming a center strip 40-feet wide. Alternate bars of the above group, plus three shorter #11 bars along each edge were extended through the center to the opposite side totaling 47 #11 bars to resist moment through the cener. As the moment decreased toward the outer edge of mat, alternate bars were discontinued in two stages leaving #11 bars on 2-foot centers at the extreme outer edges.

In computing transverse reinforcing requirements for the top of mat, negative moment on the windward side caused maximum tension at the face of the step. Here, 41 #11 bars were placed on one-foot centers with alternate bars discontinued in two stages both toward the outside and toward the center, leaving #11 bars at 4-foot to run continuously through the center. In computing this moment, only the weight of the overburden directly above the mat, plus the concrete in the mat, was considered acting downward.

The heaviest reinforcement in the opposite direction or parallel to the longitudinal axis of the pedestal was also required for load combination 2. Assuming the wind from a direction parallel to the longitudinal axis of the pedestal, tension from the wind moment on the leeward vessel combining with the effect of soil pressure produced maximum tension in the top of pedestal. This was near the inside face of the leeward tower. Assuming all the tension to be resisted by longitudinal steel alone, 22 #11 longitudinal bars were placed for this purpose in the top of pedestal. For the same combination of forces, tension in the bottom of the mat near the inside face of the windward tower required 47 #10 longitudinal bars. These were placed in a 20-foot wide strip through the center of foundation. Other reinforcement in the longitudinal direction was of a nominal nature and was placed in sufficient quantities to assure proper continuity.

**Shear Key.** It was first considered desirable to specify a continuous concrete pour between the mat and pedestals thus providing the best possible shear connection between the sections. Several factors making a continuous pour impractical were excessive dead loads on forms; inaccessibility; possible difficulty in positioning bolts; and unnecessary exposure of the excavation to weather. A large portion of the anchor bolts and pedestal reinforcing totaling some eleven tons would normally require support from pedestal form work and create a support problem. Concrete placement in the center portion of the mat would be difficult with all pedestal reinforcing and bolts in place. It was felt that accuracy in positioning anchor bolts might be sacrificed if a continuous pour was made. Assuming a continuous pour, the excavation would be exposed to weather longer before pouring could begin, thereby subjecting the soil below the footing level to detrimental change in moisture content.

In order to eliminate these disadvantages, a construction joint was designed between the step and pedestal so that the mat and step could be poured first. A 14-foot, 6-inch wide by 1-inch deep recess centered beneath each tower provided a four way shear key between step and pedestal. This recess also provided additional depth for maximum bolt anchorage.

**Vertical Reinforcing.** Particular attention was given to the selection of adequate vertical reinforcing through the center of foundation, tying the mat and pedestal together, because of the unusually high vessel overturning moment. The two, fourteen and one-half foot octagons were first assumed to act as separate round stems and the connecting center section neglected. They were then analyzed as round sections acting in bending and direct stress, the critical section being taken at the construction joint. This analysis resulted in a total of 120 square inches of vertical bars required for each stem. Under this assumption, these stems could transfer all of the over-turning moment from the towers without influence


### About the Author

**Edward V. French** is a senior structural design engineer with Phillips Petroleum Company, Bartlesville. He directs the structual and civil engineering design phase of assigned projects. Holder of a B.S. degree in civil engineering from the University of Missouri. He has been with Phillips in the Engineering Department since his graduation in 1952. Previous to this time he had two years' experience in general construction work.

from the connecting center section. This connecting section became functional when the full depth of the foundation was considered a flexural member resisting a moment in the transverse and longitudinal directions.

For vertical bars in each stem, 120 #9 bars were arranged into two rows, one row on either side of the anchor bolt circle. It was felt that in placing these bars in two rows, stress from the anchor bolts would be transferred more evenly and that any tendency for the concrete to separate at the construction joint would be minimized. Additional #9 bars were then spaced on 1-foot centers along each side of the connecting center section to prevent separation at the joint when the entire foundation acted in flexure. Figure 2 shows the foundation after the first pour was completed and it also shows the vertical bars and the keyed construction joint used to tie the mat and pedestal together.

**Gin Pole Bases.** The possibility of combining a concrete base, which would support and anchor the tower erection gin poles was considered. By providing such supports, considerable time and labor could be saved when setting the poles by eliminating the need for tying down the pole bases. The position of each tower prior to raising was planned with the tower lying at 45° to the main foundation axis. The pole bases at the closest possible position would straddle either tower on approximately 30-foot centers. Figure 1 shows the poles with the 10-foot by 203-foot tower free of the ground support. When the foundation was analyzed, applying concentrated vertical reactions from the poles spaced at 30-foot centers, it was found that tension across the top of the concrete might cause extensive cracking. This cracking, although probably not detrimental, was undesirable and to prevent it, additional heavy reinforcement would be required. The estimated additional cost of materials to provide these integral foundations was estimated at $2,000. This was considered too costly for the advantages offered and the plan was abandoned. As an alternate method, the gin pole bases were set outward and placed on timber cribbing completely clear of the tower foundation with cables providing the necessary anchorage.

**Leveling The Towers.** The pedestals were poured to within 2 inches of the finished elevation. As the towers were erected, the base rings were set on a series of steel shims which had been previously leveled. Final leveling of the towers was then accomplished by adjusting shims and anchor bolt nuts. After all adjustments were completed, two inches of grout was placed across the top of pedestal and beneath the tower base rings. Each anchor bolt was torqued to an initial stress of 45,000 psi. No inconvenience was reported by the contractor because the anchor bolts projected two feet above the concrete. Neither was there any difficulty reported in regard to spacing anchor bolts to match the tower base rings.

**Materials.** A total of 383 cubic yards of concrete and 27 tons of reinforcing steel was placed in the foundation. As mentioned previously, no large savings, if any, in concrete materials were realized over those required for two independent foundations. This was substantiated by further experience when a third tower of similar proportions (10½ feet x 177 feet) was designed and installed simultaneously, nearby. This tower was placed on the usual mat and pedestal octagonal foundation and required only 140 cubic yards of concrete. However, under the circumstances which established the design conditions, there were still advantages in the saving of space in conformance with the best piping arrangement and in the possible vibration damping effect gained.

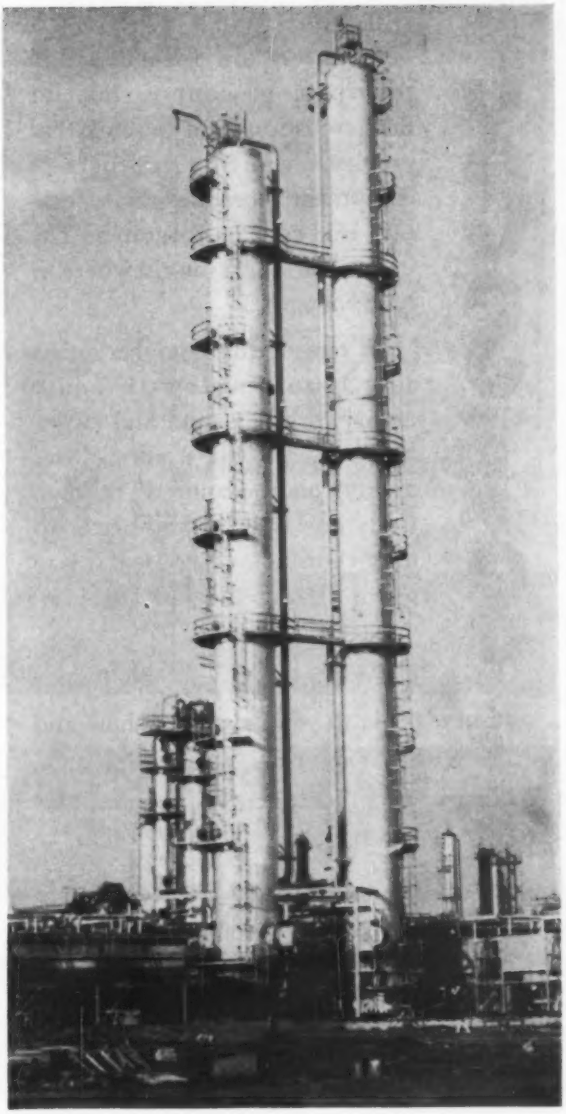

**FIGURE 4—Tower installation complete with insulation, platform and piping.**

**Trend.** There is a definite trend in the industry toward the use of taller fractionating vessels containing more trays. The experience acquired during the design and installation of these towers will be useful in determining the feasibility and planning of future units. ##

# COSTS

Costs—that's the thing.

Engineers are interested in principles, of course, but it's dangerous for them to think that problems relating to costs of equipment, processes and operation can ever be forgotten. The dollar mark here, as elsewhere, is quite potent.

So one of the engineer's first aims is to develop an acute ability to understand and evaluate costs. And like a muscle, this ability once acquired through study and observation, needs almost continuous exercise if it is to remain healthy and develop.

PR's special report on costs will afford this exercise. It will add new *tricks* to your cost know-how and will strengthen and expand your knowledge of the successful design and operation of a process plant.

Basically, an evaluation is a step-by-step study of each of the components which make up a whole project. And while you may be familiar with these steps, the difficulty is in applying them to a particular problem. In this special report on costs, you'll find several of these problems discussed in detail.

Our authors in this issue offer some excellent help for you in handling manufacturing costs, controlling total costs, and process equipment and storage costs. Here's a quick rundown on what you will find:


How Raw Materials Affect Costs..108
How to Control Total Costs.....112
How to Determine Low
Temperature Storage Costs.....115
How to Estimate Fractionating
Column Costs .....119


*Thomas C. Ponder*

# Here's How Raw

## Use this tool to study a supplier's operation and find the fair cost of raw materials


**Alfred T. Bogen**
The Chemstrand Corp., Pensacola, Florida


INCREASING ATTENTION is being directed toward the development of effective manufacturing cost control programs throughout industry as a consequence of the combined pressures of spiraling costs and increased competition that have steadily squeezed profits in recent years. These programs usually emphasize the reduction of variable costs, with attention focused primarily on

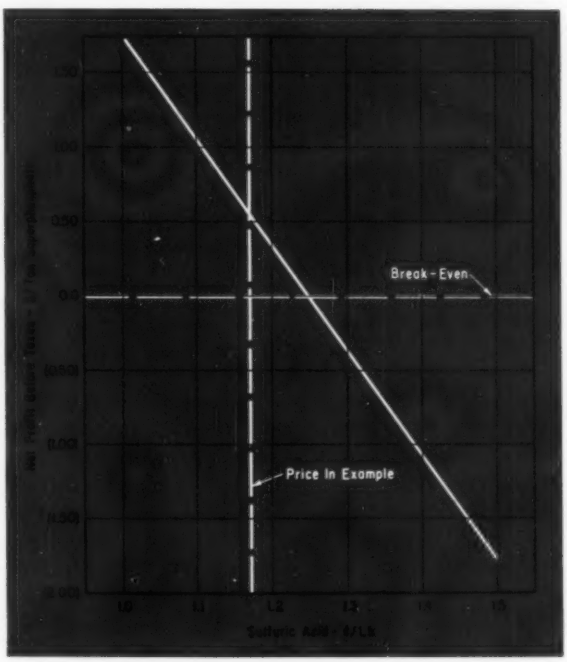


**FIGURE 1—Shows the variation of net profit before taxes in superphosphate fertilizer manufacture with changes in sulfuric acid prices. When sales and general overhead costs are set at 4 percent of gross sales, the chart shows that a 7-percent increase in acid cost would mean a deficit operation. This increase is less than 0.1 cent per pound in the price paid for acid.**

A SPECIAL REPORT

# Materials Affect Cost

material usage and yields, manpower requirements, maintenance costs, and utilities consumption. Such an approach is certainly sound and properly should form the foundation of any effective cost control program.

**Raw Materials.** There is another facet of the matter, however, which also has an important bearing on manufacturing costs; namely the prices paid for raw materials. In certain instances the potential for reducing manufacturing costs through lower raw material purchase prices may not have been fully appreciated or exploited, since purchasing and operation responsibilities are frequently vested in separate groups. It is the purpose here, therefore, to illustrate how raw material costs can be of prime importance in maintaining a profitable operation and, further, to outline a means for gauging the potential for raw materials purchase price reductions.

**Process Influence.** Usually the influence of raw material prices on over-all manufacturing costs is inversely proportional to the amount and the complexity of the processing required to convert the raw material into a finished product. For example, the brass stock and the tool steel that constitute the principal raw materials in a high quality watch represent only a minor percentage of the total manufacturing cost, even though they may cost $2-$3 per pound. In this case labor is the principal constituent of manufacturing costs and the potential for materially reducing manufacturing costs with cheaper raw materials is not a promising possibility.

In the petroleum and chemical industries where large volume highly instrumented continuous operations are quite common, raw material costs can be a dominant factor in manufacturing cost control. Probably no one is more conscious of this rather axiomatic statement than the average Gulf Coast refiner, who in December 1959 had an average total product realization of only $3.58 per barrel from crude oil priced at about $3 per barrel.[1]

**Example.** To further emphasize this point, let us consider the matter of raw materials purchasing for a 500 T/D superphosphate fertilizer plant. It has been reported that the principal raw materials for this operation, phosphate rock and sulfuric acid, together cost $12.15/ton of finished fertilizer, or slightly more than 82 percent of the $14.79/ton total manufacturing cost.[2] Moreover, the cost of sulfuric acid alone was reported to be $8.46/ton of fertilizer, or 57 percent of the total production cost. With superphosphate fertilizer selling for $16/ton, it is apparent that profit margins could be

## 5 Steps in evaluating the economics of a raw material supplier's operation

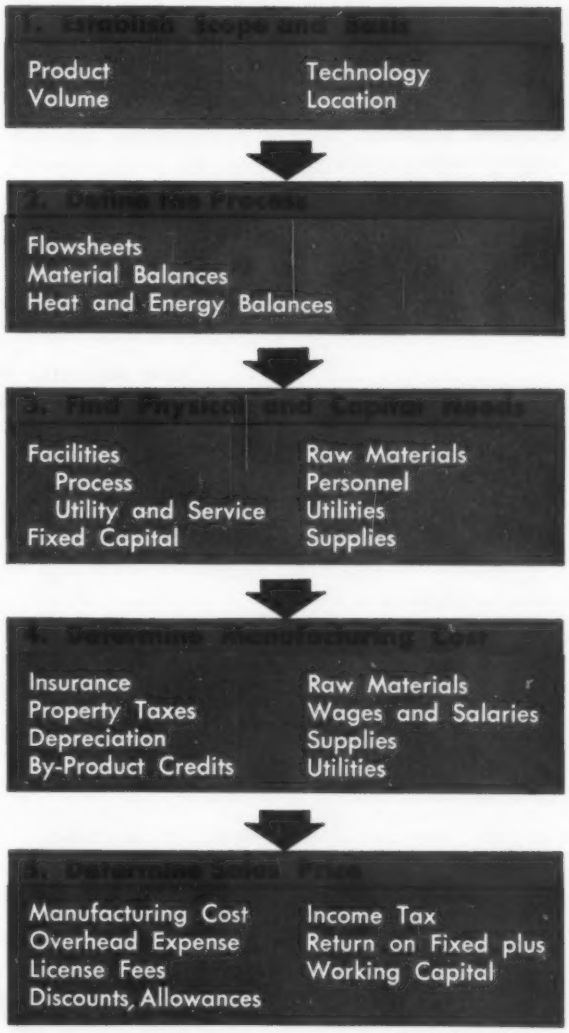


**FIGURE 2—Follow these five steps and your bargaining pencil can be much sharper when negotiating raw material purchase contracts.**

greatly affected by raw material costs, particularly sulfuric acid prices. The magnitude of this effect is illustrated in Figure 1, which shows the variation of net profit before taxes with changes in sulfuric acid prices when sales and general overhead costs are set at 4 percent of gross sales. An inspection of this chart shows that a 7 percent increase in sulfuric acid cost would mean a deficit operation. This increase is less than 0.1c/lb. in the price paid for acid!

**Raw Material Worth.** How can those engaged in operations where raw materials represent a major manufacturing cost item be reasonably certain that raw material purchase prices are at a level that represents a fair exchange for both the purchaser and the supplier? Experience has shown the economic evaluation to be an excellent tool for one to use in answering such questions. This is especially true in the case of many chemical raw materials where the technology and the equipment requirements are well known and a minimum of speculation is required for reasonable approximations.

**Evaluate Supplier.** Since it is improbable that any supplier would knowingly reveal the inner economic secrets of his business, how may one concerned with raw material purchasing secure the required economic evaluation? The solution to this problem lies within the capabilities of that group in his company, or the outside consultant, who normally prepares the economic evaluations required by top management to direct the corporation's regular business activities. This is because the techniques and general approach applicable to the analysis of a supplier's economic position are basically no different than for an evaluation of one's own operations. Naturally, more unknowns are involved in the analysis of an outsider's operations, and this tends to reduce evaluation accuracy. This is not a serious limitation, however, since experience has shown that a detailed estimation of all unknowns, even on the basis of educated assumption, improves evaluation accuracy markedly. It is the rare exception therefore, when an experienced engineer can not approximate the economics of commercial operation with sufficient accuracy to provide a worthwhile guide for purchasing negotiations.

Estimation of the economics surrounding a supplier's operations may be divided into five basic steps which are common to any economic evaluation. As outlined in Figure 2, the first step involves establishment of the basic technology, mode, and scope of the operation in question. In those instances where one has operations of a similar character, these data may be readily available. Where such is not the case, the more likely sources of information are patents, technical and trade journals, and standard reference works.

With this information at hand, it is not difficult for the engineer to complete step two: Preparation of the flow sheets and material balances that describe the operation in specific detail.

Next, the engineer utilizes the previously developed information to estimate equipment, raw materials, personnel, and utilities requirements and costs. In estimating capital investments, he must be careful not to overlook those service and utility facilities required to sup-

**RAW MATERIAL SUPPLIER'S OPERATION**

**10,000,000 POUNDS PER YEAR OF COMPOUND XY**

**TABLE 1—Manufacturing Cost Summary**

10MM Lb/Year Compound XY

| | Unit | Unit Cost | Quantity | Annual $M | ¢/Lb XY |
|---|---|---|---|---|---|
| **RAW MATERIALS** | | | | | |
| Compound X | M Lb. | $30.00 | 5,500 | $ 165 | 1.7¢ |
| Compound Y | M Lb. | 17.50 | 5,380 | 94 | 0.9 |
| Others | M Lb. | 10.00 | 260 | 3 | * |
| Total | | | | $ 262 | 2.6¢ |
| **WAGES & SALARIES** | | | | | |
| Wages | Man-Year | $5,000 | 48 | $ 240 | 2.4¢ |
| Salaries | Man-Year | $7,000 | 10 | 70 | 0.7 |
| Security | 10% of Wages & Salaries | | | 31 | 0.3 |
| Total | | | | $ 341 | 3.4¢ |
| **SUPPLIES** | $1,000/Operating Employe | | | $ 48 | 0.5¢ |
| **UTILITIES** | | | | | |
| Steam | M Lb. | $ 0.40 | 45,000 | $ 18 | 0.2¢ |
| Electricity | MKWH | 10.00 | 6,000 | 60 | 0.6 |
| Cooling Water | M Gal. | 0.02 | 128,000 | 3 | * |
| Others | | | | 15 | 0.2 |
| Total | | | | $ 96 | 1.0¢ |
| **SERVICES** | | | | | |
| Technical | 3¢/Lb. Product | | | $ 300 | 3.0¢ |
| General | $1,500/Employe | | | 87 | 0.9 |
| Total | | | | $ 387 | 3.9¢ |
| **OCCUPANCY** | | | | | |
| Maintenance | 4% of Investment | | | $ 400 | 4.0¢ |
| Shops & Stores | 2% of Investment | | | 200 | 2.0 |
| Insurance & Taxes | 1% of Investment | | | 100 | 1.0 |
| Depreciation | 6% of Investment | | | 600 | 6.0 |
| Total | | | | $1,300 | 13.0¢ |
| **TOTAL MANUFACTURING COST** | | | | $2,434 | 24.4¢ |

*Insignificant Amount.

**TABLE 2—Sale Price Summary**

10MM Lb/Year Compound XY

| | $M | $/Lb. |
|---|---|---|
| **CAPITAL INVESTMENT** | | |
| Fixed Investment | | |
| Battery Limits | $10,000 | $1.000 |
| Allocated—Utilities | 600 | 0.060 |
| Services | 400 | 0.040 |
| Shops | 200 | 0.020 |
| Total | $11,200 | $1.120 |
| Working Capital | $ 490 | $0.049 |
| **TOTAL CAPITAL INVESTMENT** | $11,690 | $1.169 |
| **RETURN ON TOTAL INVESTMENT (AFTER TAXES)** | 15% | |
| **ANNUAL NET PROFIT** | $ 1,753 | $0.175 |
| **ANNUAL INCOME TAX** | 1,753 | 0.175 |
| **ANNUAL GROSS PROFIT** | $ 3,506 | $0.350 |
| **ANNUAL COST OF SALES** | | |
| Manufacturing Cost | $ 2,434 | $0.244 |
| Corporate Overhead @ 4% | 247 | 0.024 |
| Total | $ 2,681 | $0.268 |
| **ANNUAL SALES REVENUE** | $ 6,187 | $0.618 |
| **SELLING PRICE—¢/LB.** | 61.8¢/Lb. | |

*Here's his cost* ... *and selling price*

port the operation, such as cafeterias, shops, boiler houses, and locker rooms. In the Chemical and Petroleum industry these items can represent 35-40 percent of the total investment; however, they are frequently under-estimated and sometimes overlooked entirely.

The remaining two steps involve use of the data previously established to compute the manufacturing cost and a sale price. This is a relatively straightforward procedure that follows established accounting practices. The only difficulty may be in establishing realistic working capital, overhead, and employee benefit costs. The advice and guidance of one experienced in accounting matters, however, will be quite helpful in resolving these points through reasonable approximations based on experience or published general approximations.

**Tools.** With the completion of a comprehensive economic evaluation of the supplier's operation, the engineer can now provide those concerned with the purchase of raw materials with some effective tools for contract negotiations. These usually consist of a manufacturing cost summary, a sales price summary, and sale price variation curves showing the effect of raw material costs on the supplier's operation; examples are shown in Tables 1 and 2 and Figure 3. Thus, armed with a realistic approximation of the supplier's costs and profit margin and his own knowledge of general market conditions, the purchasing director can approach purchase contract negotiations with a far better understanding of the limits within which he can negotiate and the minimum price that will be acceptable to both himself and the supplier.

In addition, the economic evaluation provides a valuable insight as to how future changes in the supplier's basic raw material, labor, and energy costs will affect the supplier's profit margin and product sale price. Further, it alerts the purchasing director to those factors that should be observed in future general market changes for their effect on his raw material costs. Another use of the economic evaluation is in choosing between alternate processes to a common raw material to insure that the process selected offers both immediate and long term advantages in cost and technology. Finally, the economic evaluation is useful for weighing the advantages of volume purchase and can also be of considerable value in identifying potential new supply sources.

**Engineering and Accounting.** Throughout this discussion emphasis has been placed on the need for engineering talent in preparing the economic evaluation. This is because only an experienced engineer is capable of performing what is possibly the most difficult and important part of the evaluation; namely, reducing fragmentary information to a realistic approximation of the process, the capital investment, and the raw material, personnel, and utilities usages involved. Even so, the completed economic evaluation is by no means an exclusive engineering production. From the beginning the engineer must look to other groups for advice and guidance in matters that lie outside his special field of knowledge.

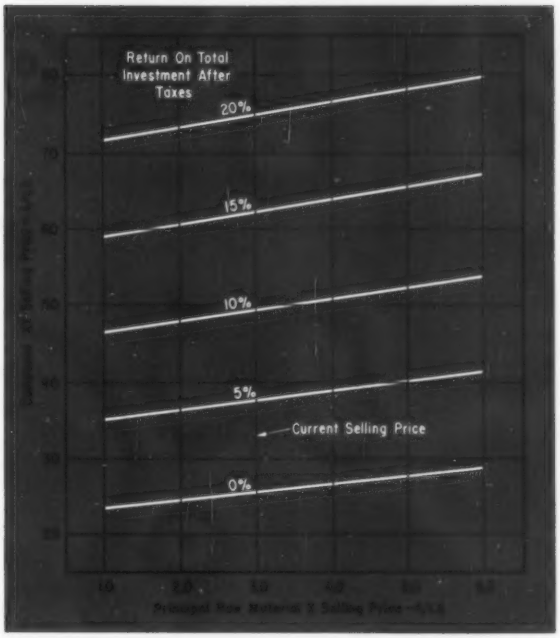


**FIGURE 3—Here's how price of 10 million pounds per year of compound XY is affected by selling price of raw material X for various investment return rates.**

Accordingly, it must be fully recognized that besides purchasing, other corporate groups such as Accounting, Manufacturing, and Research, also play a vital role in the successful completion of any economic study. As in any endeavor, effective teamwork and cooperation is the key to the successful use of economic evaluations in the purchasing function. This key, when properly applied to the task, can open new approaches to chemical raw material purchasing which in turn can materially contribute to manufacturing cost reduction.


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[1] The Oil and Gas Journal, Feb. 8, 1960, pp 187-188.

[2] Hardy, W. L., "Fertilizer Plants Costs," Industrial and Engineering Chemistry, Nov. 1956, p 41A.


## About the Author

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A SPECIAL REPORT

# How to Control Total Costs

**Here's how accounting and engineering work together to control over-all production cost**

**Kenneth J. Gutshaw**
Union Carbide Chemicals Company
New York City

IF YOU WANT to control manufacturing costs, break them down into variable cost and two types of fixed cost.

Development of the cost accounting data needed for control of production costs cannot be accomplished by the professional accountant alone. Effective control of plant costs depends upon a close working relationship between:

**1. The plant engineer,** who supplies the process and budget information required for the development of the dollar norms for control, and

**2. The professional accountant,** who, because he works with the engineer, is able to develop and modify the systems that will faithfully reproduce plant activity and report actual operating results that can logically be compared with the norms that have been established.

Since profit usually tends to be maximized by minimizing total value expended, much of the time of business managers has always been devoted to reducing the cost of doing business.

**Manufacturing Costs.** In the petrochemical business, product manufacturing cost consumes a major portion of the sales dollar and, as a result, considerable effort is concentrated on minimizing this particular cost.

**Accounting.** As in other businesses, the art of accounting is used by petrochemical manufacturers to classify, record, summarize and report in monetary terms *all* transactions and events that have an economic impact on their particular enterprise. The art of accounting, therefore, is the instrument used to determine product manufacturing cost—it is the instrument used to furnish the plant manager with the data needed to minimize his production costs and thus, improve profit margins.

This article will illustrate how cost accounting may be used to determine product cost and generate the control data that establishes the basis for action required to minimize production cost.

Because cost accounting is an art and the characteristics of manufacturing activity differ within and between industries, many systems of production cost accounting have been developed. All these systems, however, have as their common and ultimate objective, the identification of all expenditures to product—either directly or by some allocation technique. They usually differ in the manner and degree to which costs of production are segregated for purposes of management control.

## COSTS DIVIDED INTO THREE CATEGORIES

Costs of chemical production can, in general, be classified in terms of any one of three categories, i.e.:

1. **Costs that vary directly with the rate of production (direct variable costs):** items such as cost of steam, power, raw materials, certain types of labor (as in drumming or canning activity), etc.

2. **Costs that are essential to production but remain practically unchanged with wide variation in production rate (direct fixed costs):** items such as cost of maintenance labor, maintenance materials, certain catalysts, most operating labor, certain taxes, etc.

3. **Costs that are not directly related to production and remain essentially unchanged with wide variation in production rate (indirect fixed costs):** items such as cost of the Medical Dispensary, Industrial Relations Department, Plant Managers Department, Safety Department, taxes, insurance, etc.

## SIX MUSTS FOR AN ACCOUNTING SYSTEM

In order to develop the controls that are needed to help minimize these three categories of plant production cost, the plant accounting system must depend upon:

1. **A production plan** (based on a sales forecast) developed for the plant at the end of each year covering, at least, the following year.

2. **The assignment of products** expected to be manufactured to well defined plant process systems.

3. **The development of operating budgets** for the expected production activity in each process system by the person responsible for operating results (one person may, of course, be responsible for one or more systems).

4. **The assignment of the elements of the process system operating budget** to each of the three categories of plant production cost (indirect fixed costs will probably be negligible).

5. **The development of product direct variable cost standards** by "rolling up" through the process steps the costs assigned to product in each process system as variable cost.

6. **The development of budgets** for those departments classed as indirect fixed costs (this would be accomplished via decisions made by plant management).

## BUDGET CHECK BY COST RESPONSIBILITY

The development of budgets and product cost standards provides the plant manager with the datum points against which actual operating results may be measured. Deviations from these datum points represent deviations from a plan or decision and, as such, constitute areas requiring additional analysis and possibly corrective action.

What are the controls or the datum points that are used? These are, simply, the datum points developed in terms of the three categories of plant production cost and assigned (depending on who developed the underlying budgets) to a member of the organization as his share of cost responsibility.

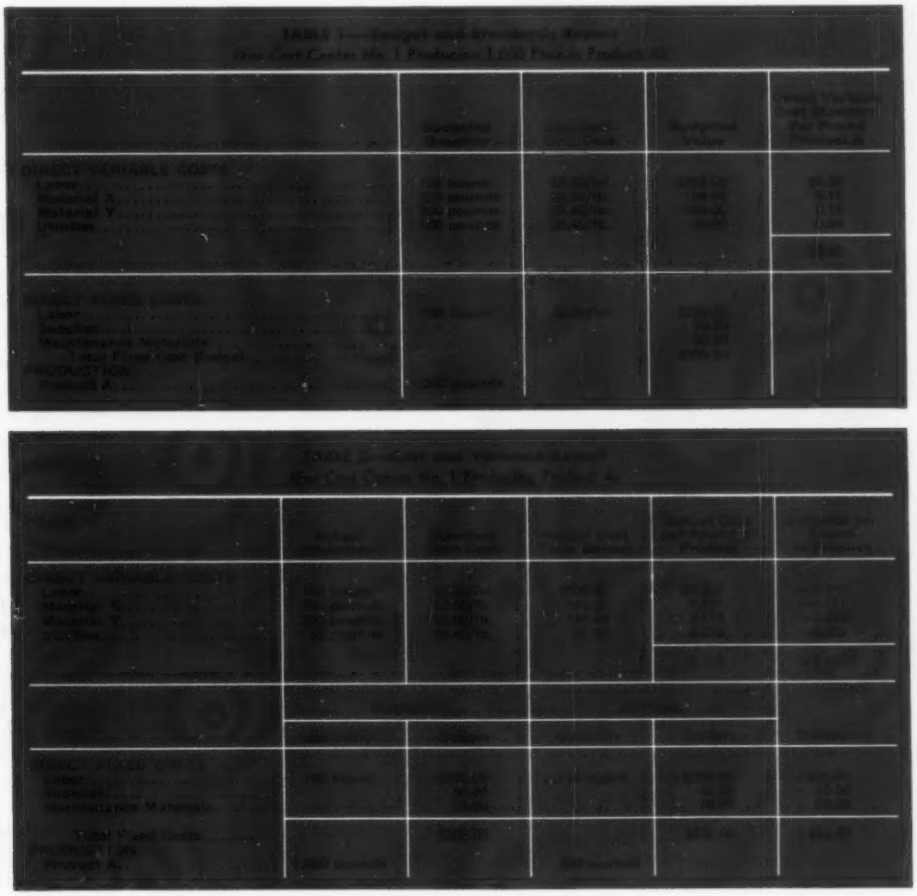
## HOW COST RESPONSIBILITY WORKS

How does cost responsibility operate to minimize plant production cost? This question may be discussed in terms of the three categories of plant production cost:

1. **Direct Variable Costs:** Since these costs vary directly with production rate, they will be essentially constant (in terms of dollars per pound of product produced) over a fairly wide range of production rates. This characteristic is valuable in that it then becomes logical to compare the actual variable cost per pound of product with the variable cost standard developed during the planning and budgeting period. Since all "variable cost" materials and labor enter a process system at a standard value any unfavorable deviation from standard that occurs in a particular process system reflects inefficient operation in that system alone.

The person responsible for operating results in such a process system has, therefore, no difficulty in detecting the results of inefficient operation and can apply corrective action.

Because all process systems in the plant are each



isolated by standard costs, the accounting data will indicate all sources of increased cost.

This type of control together with careful engineering of variable cost standards provides an effective and efficient tool for minimizing variable product cost.

**2. Direct Fixed Cost:** Although these costs are generated by activities necessary to product manufacture, they remain practically unchanged with wide variation in production rate. For this reason these costs are not expressed in terms of dollars per pound, but rather as budgeted dollars within the process system or cost center. The economic effect of any change in rate of expenditure for this type of fixed cost is readily noted via comparison of budgeted and actual cost data. The place to apply corrective action is always obvious—whether or not such action is taken must be subject to management decision.

3. **Indirect Fixed Costs:** These costs are generated by activities that do not provide immediate support of actual product manufacture. Even though these activities may be required as the result of higher management decision, the magnitude of the costs depends to a great extent on decisions made by plant management. Comparisons made with other similar plants, experimentation with size of department or reorganization and so on may be used by plant management to determine the optimum size of such departments as Industrial Relations, Shipping, Medical Dispensary, etc. Once the plant manager has made a decision on the amount of money he thinks he should spend on these activities to provide the service required, the budgets that have been developed become the controls that will be used to measure any future variance with his decisions.

### EXAMPLE

In order to illustrate a cost control system that employs direct variable costs, direct variable cost standards and budgets, the following simplified example is presented in Tables 1 and 2. This example does not consider indirect fixed costs.

Table 1 illustrates the development of a process system or cost center budget and direct variable cost standards for the production of a single product. The expected or budgeted costs for the cost center are segregated into direct variable and direct fixed components. The budgeted values for all expenditures are based upon a planned production and sales of 1,000 pounds of product "A" for the period. All expected usages of direct materials, labor, etc. in the department are values at a standard price and a standard direct variable cost of 65 cents per pound is developed for product "A." Likewise, all elements of direct fixed expense, totalling $300 are budgeted and portrayed in the lower portion of Table 1.

Table 2 is the monthly cost and variance report showing a comparison of planned versus actual expenditures for Cost Center 1, for both direct fixed and direct variable cost elements. The data for direct variable costs, are portrayed both in total dollars and unit costs, and the resulting variances expressed as the unit costs per pound of product "A." It is emphasized that these direct variable cost deviations are for this process system alone and represent this supervisor's efficient or inefficient use of labor and materials, since the use of standard costs eliminates any fluctuation in costs originating in other departments.

The direct fixed cost budget for the cost center is compared with actual expenditures and the differences reported in total dollars. If the differences between budgeted and actual expenditures are of a significant nature, they are subject to management scrutiny. No attempt is made to express the direct fixed costs as a unit cost per pound of product.

### TIE ALL PLANT COSTS TO PRODUCT

Although we might agree at this point that the type of plant cost accounting that has been described is very well suited to the plant manager's business objective of minimizing cost, the problem of identifying all plant expenditures to product certainly remains unanswered. This identification must be done eventually in order to determine whether or not sales prices furnish margin for adequate profit and to determine inventory values for governmental and other purposes.

The identification of petrochemical plant expenditures to product may be accomplished as follows:

**1.** Direct variable costs constitute the **major portion** of product cost—the accounting system generates direct variable cost completely identified to product.

**2.** The accounting system generates direct fixed cost identified to process system and, therefore, to product. In those cases where products feed as intermediates from one process system to another, the direct fixed costs must be "rolled up" accordingly, in order to obtain proper identification to product.

**3.** The accounting system generates indirect fixed costs completely unidentified to product or process system. Here, as in all other accounting systems that have ever been devised, arbitrary methods must be developed to allocate this type of cost to process system. Once the latter has been accomplished identification to product proceeds as in the case of direct fixed costs.

*As far as minimizing the cost of a plant operation is concerned, there is no need to identify all plant costs to product.* The frequency with which all plant expenditures are identified to product depends entirely on the reporting and business requirements that exist within the company but outside the manufacturing system. Generally, a quarterly basis is considered adequate for these requirements. ##

## About the Author

**Kenneth J. Gutshaw** is control manager of Union Carbide Chemicals Company. His duties include company planning and control activities. His entire professional career has been with Carbide having worked in the Development Department, Production Department-Synthetic Resins and Production Planning. He was graduated from Notre Dame University in 1940 with a B.S. in chemical engineering.

A SPECIAL REPORT

# How to Determine Low-Temperature Storage Costs

**Greater profits can result from using these data to evaluate and select optimum storage conditions**

**John T. Horton**
Chicago Bridge and Iron Company
Chicago

RESULTS FROM an extensive computer study, shown in graphical form, permit rapid selection of the most economical type of storage at optimum conditions. Basic criteria for engineering design of LPG storage are: safety and economy. The engineer's job is to find the most economical design compatible with these two criteria. While this study is devoted to storage of liquefied petroleum gas—generally mixtures of hydrocarbons from $C_2$ to $C_5$—it is also applicable to other products which are gaseous at ordinary conditions.

LPG above-ground storage in metallic containers has several advantages:

- Quantity of product in storage may be easily determined by conventional gaging techniques.
- Storage vessels are always accessible for inspection.
- Storage capacity can be increased easily.
- Product composition will remain constant throughout the storage period, no contaminants can be picked up either from or through the vessel.
- There is no loss of product.

**Design Data.** It is assumed that complete information and necessary data are available for designing liquefied petroleum gas storage including the following:

- **The product to be stored.** In most cases, the product will be a mixture.
- **The required quantity of storage.** Usually given in volumetric units which must be reducible to units of mass.
- **The way in which the product reaches storage.** Rate of flow into storage, temperature of incoming stream, pressure of incoming stream. In most cases,

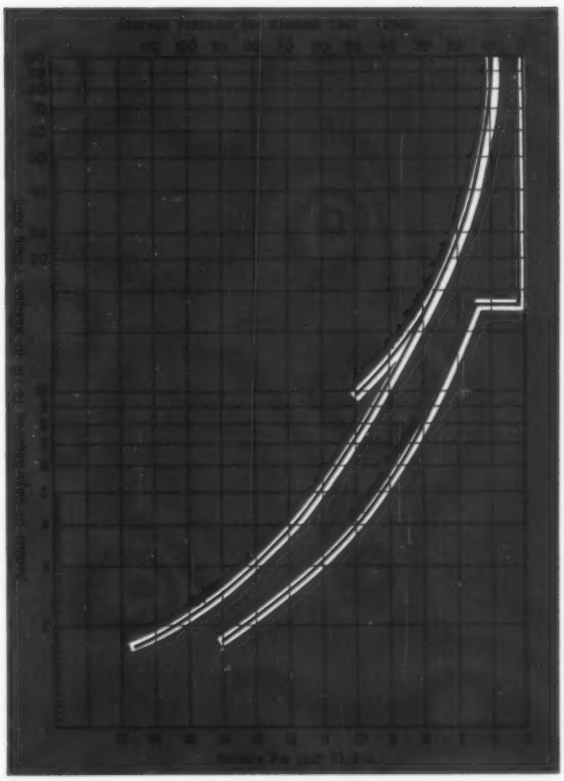


**FIGURE 1—Using number of days required to fill the storage, here are the costs and optimum pressure for various types of storage. Based on an incoming stream of propane at 70° F, the lower curve gives most economical storage pressure independent of system capacity and the upper curve shows capital cost in dollars per barrel (60° F bbl) for a system of 20,000 barrels capacity.**

## COSTS

### *Low-Temperature Storage Costs*

inflow will not be continuous; for accurate design, the input conditions should be known as a function of time.

• **The manner in which product is removed from storage.** Again it is best to have information in the form of a flow-rate vs. time curve. Temperature and pressure requirements of the out-flowing stream must also be known.

• **Civil engineering information:** foundation conditions, naturally occurring loads (e.g., wind and earthquake), and data on corrosive agents in the atmosphere.

• **Data to permit evaluation of refrigerated alternatives:** such as atmospheric temperature and pressure variations, availability, characteristics and cost of electric power and fuels and possible source of cooling water.

**Types of Storage.** Above-ground storage, in the case under discussion, can be divided into three classes:

**1.** "Full Pressure" storage in vessels usually designed for a pressure of 250 psig. Usually such vessels are not insulated.

**2.** Pressure storage at reduced temperature ranging from insulated spheres designed for about 200 psig with no refrigeration (the insulation serves to smooth out changes in pressure resulting from diurnal temperature variation) to spheres designed for about 15 psig (about —13° F), heavily insulated and requiring refrigeration.

**3.** Storage at essentially atmospheric pressure in flat-bottom, dome roofed tanks designed for 1.0 psig and operating between 0.3 and 0.8 psig. This class requires the greatest amount of insulation and refrigerating equipment.

An example is shown using Class 2 and Class 3 types of storage for pure propane under varying conditions of capacity, in-flow and out-flow, and the physical conditions of each type of storage.

Figure 1 is a graphical presentation of capital cost analysis done on a computer for a continuous incoming stream of pure propane at 70° F. The independent variable is number of days required to fill storage at the incoming stream rate of flow. The lower curve gives optimum (most economical) storage pressure which is independent of system capacity and the upper curve shows capital cost in dollars per barrel (60° F barrel) for a system of 20,000-barrel capacity. Figure 2 shows the adjustment required to apply cost figures from Figure 1 to systems of from 5,000-barrel to 80,000-barrel capacity.

#### EXAMPLE

As an example, consider two systems for storage of 30,000 barrels (60°) of pure propane.

| | | |
|---|---|---|
| Capacity of system in BBL at 60° F | 30,000 | |
| Incoming flow: | | |
| Temperature | 70° F | 70° F |
| Rate at stream temperature | 200 B/Hr @ 70° F | 20 B/Hr @ 70° F |
| Rate in 60°F BBL/Day | 200 × 24 × 31.24/31.75 = 4720 | 20 × 24 × 31.24/31.75 = 472 |
| Days to fill | 30,000/4720 = 6.35 | 30,000/472 = 63.5 |
| Optimum Pressure (Fig. 1) | 35 psig | 1 psig |
| Storage Class | 2 | 3 |
| Optimum Temperature* | +14.5° F | —43.2° F |
| Weight Density* | 33.15 lb/ft³ | 36.25 lb/ft³ |
| Water Capacity $\left(30{,}000 \times \frac{\gamma\,(60)}{\gamma\,(\text{storage})}\right)$ | 28,720 BBL | 26,270 BBL |
| Cost/BBL For 2OMB System (Fig. 1) | $10.35 | $6.00 |
| Adjustment For 3OMB System (Fig. 2) | —$ 0.51 | —$0.50 |
| Net Per Barrel | $ 9.84 | $5.50 |

* Data from *Handbook of Butane-Propane Gases*, George H. Finley (ed), Western Business Papers, Inc., Los Angeles, 1935, Page 9.

These figures and comparisons include costs for vessels, insulation, refrigerating equipment for incoming stream and holding requirements plus holding standby, piping, control system, foundations (assuming soil good for 4,000 lb/ft²) and buildings required to house refrigerating equipment and controls.

Storage in flat-bottom tanks designed for a vapor phase pressure of one pound per square inch gauge and operating normally over a pressure range of 0.3 to 0.8 psig becomes the most economical system when time required to fill storage capacity exceeds eighteen days (assuming a 70° F incoming stream—the Q/q ratio will change with the incoming stream temperature).

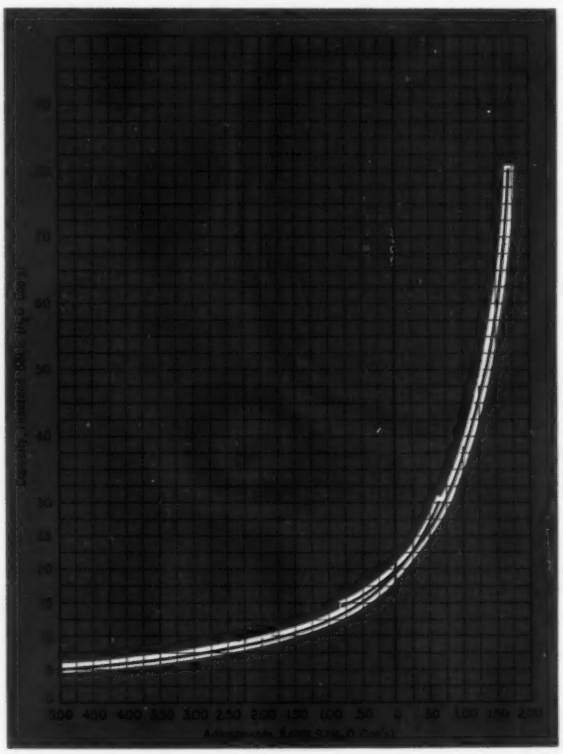


**FIGURE 2—Use these adjustments for capacities other than 20,000 barrels. These factors are based on dollars per barrel of water capacity of vessel to maximum liquid level.**

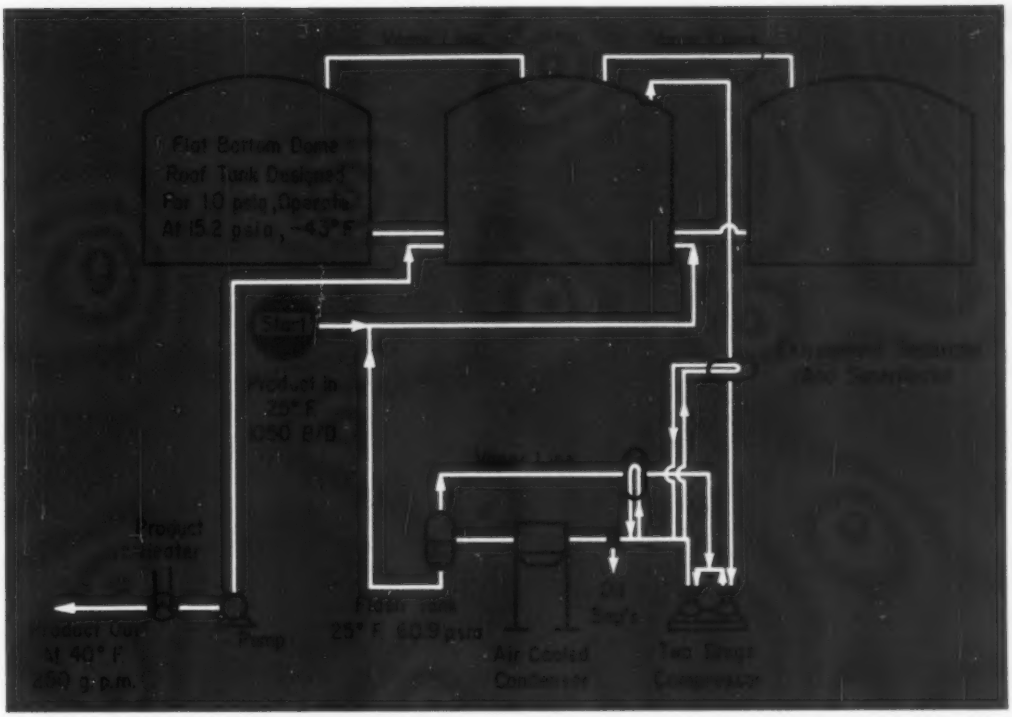


**FIGURE 3—Arrangement of equipment used in the plant study for a total storage capacity of 274,000 barrels.**

## PLANT STUDY

As an example of this type of storage, we may consider storage at a natural gasoline plant using a refrigerated oil absorption system of the type described by Faulkner & Albiol.[1]

For this discussion, we have increased the propane recovery rate tenfold—from 424.4 moles per day to 4244 moles per day or approximately 1,050 barrels (60° F) per day. Storage is in three flat-bottom, dome-roofed tanks with water capacity of 80,000 barrels each which, when filled with propane at —44° F, hold the equivalent of 91,600 barrels at 60° F for a total capacity of 274,800 barrels.

Figure 3 is a schematic representation of the storage facilities showing the container and product flows. Controls (not shown Figure 3) would be pneumatically operated (3-15 pound air signals) with the refrigeration system controlled by tank vapor-phase pressure.

Vapor pressure may be changed by two mechanisms:

**1.** Heat input will raise product temperature and, therefore, vapor pressure. Heat input may come from two sources:

(a) Sensible heat of incoming product stream, approximately 37.4 Btu/lb or 469,000 Btu/hr for a stream of 4244 moles/day.

(b) Heat transfer from surroundings, using the double wall storage vessel, will amount to about 74,000 Btu/hr for one 80MB tank with outer wall temperature of 110° F.

**2.** Flow of material into or out of storage will change the vapor space volume.

**Operation.** When tank pressure rises to 15.5 psia, a pressure-controller starts the vapor recompression system which continues to operate until pressure falls to 15.0 psia. For this system, 40 tons of refrigeration are required by incoming product flow and 20 tons by heat transfer from surroundings. To provide flexibility of operation and to permit maintenance during operations, four refrigerating systems are used, each of 20-tons capacity.

In addition, a standby electric power generator is provided having a capacity sufficient to run one of the refrigerating units, the foundation heaters and the control system so that in the event of plant-power failure, product need not be vented.

**Vacuum Breaker.** If product must be removed from storage at a high rate, it may become necessary to provide means of preventing vacuum in the tank. A vacuum relief valve is, of course, supplied but it is highly undesirable to allow air to enter the tanks. For the present example, all that it required is to provide a small line returning to the flash tank from the outgoing 40° F stream and another line from the flash tank vapor space to the storage tank vapor space. A controller operating between 0.0 and 0.2 psig would be supplied to open and close valves in each of these additional lines.

If tank pressure dropped to atmospheric, both valves would open, a small quantity of propane at 40° F (less than one gallon per minute for a 250-gpm output) would flow to the flash tank, part would evaporate and the resulting vapor—sufficient to replace the volume of liquid being pumped out—would flow directly to the storage tank vapor space. To provide for possible failure in this volume-replacement system, a shutoff valve controlled by storage tank pressure should be placed in the discharge line, set to close at a vacuum of 0.1 psi.

## COSTS

*Low-Temperature Storage Costs*

**TABLE 1—PROPANE STORAGE AT A GAS PLANT**

**ASSUME: Incoming Stream At 1050 BBL/Day, 25° F.**
**Selling Price 3.5¢/Gal for 261 Days, 5¢/Gal for 104 Days.**
**Cost of Power = 1¢/kwh.**

| | Conventional Storage, Ten Days Production At 1,050 BPD | | Refrigerated Storage, 261 Days At 1,050 PBD | |
|---|---|---|---|---|
| Quantity Stored | 10,500 Bbls. | | 274,050 Bbls. | |
| Gross Price of Product | 114 x 2.10 x 1050 | $251,300 | 365 x 2.10 x 1050 | $805,000 |
| | 251 x 1.47 x 1050 | 387,400 | 0 x 1.47 | —0— |
| | | $638,700 | | $805,000 |
| Cost of Tankage (Incl Fndn, Insul) | $147,000 | | $930,000 | |
| Cost of Mechanical & Electrical | 33,000 | | 175,000 | |
| | $180,000 | | $1,105,000 | |
| Operating Manpower | | $8,000 | | $9,000 |
| Maintenance | | 3,000 | | 8,000 |
| Power @ 1¢/kwh | | 200 | | 11,280 |
| | | $11,200 | | $28,280 |
| Depreciation @ 10 percent | | 18,000 | | 110,500 |
| | | $29,200 | | $138,780 |

**ECONOMIC COMPARISON**

| | | |
|---|---|---|
| Increase In Value of Sales | $805,000 — $638,700 = | $166,300 |
| Increase In Annual Cost | $138,780 — $ 29,200 = | 109,580 |
| Increase In Annual Gross | | $56,880 |
| Tax At 52 Percent | | 29,580 |
| Increase In Annual Net | | $27,300 |
| Difference In Depeciation Allowance | $ 27,300<br>92,500 | |
| Funds Available to "Payout" | $119,800 | |
| Difference In Capital Cost | $1,105,000 — $180,000 = $925,000 | |

$$\text{"Payout" Time} = \frac{925{,}000}{119{,}800} = 7.7 \text{ Years.}$$

**Economic Analysis.** Table 1 shows an economic analysis of this storage based upon the assumption that minimum storage of ten days' production would be required to allow flexibility in plant operation and economical operation of loading facilities. Both systems considered in Table 1 include storage vessels, foundations and all electrical, mechanical and insulation work required to take propane at the incoming stream conditions, change its temperature to that required by storage vessel design, maintain that temperature for the storage period and discharge from storage at a maximum rate of 250 gpm, minimum temperature of +40° F and minimum pressure of 200 psig.

**Annual Sales.** The difference in annual sales stated in Table 1 takes into account only a possible difference in posted price between summer and winter, no consideration is given to the possibility of "distress sales" down time or the possible sales advantage inherent in having a large supply of product available in times of highest seasonal demand.

**Other Products.** Although this analysis concerns only propane, gasoline plants will, of course, produce other products most of which will be subject to seasonal variation in demand. Similar analyses can be made of butane and natural gasoline storage economics. Natural gasoline has been stored in large quantities at intermediate pressures in "spheroids" and butane is conventionally stored in spheres.

In conjunction with a system storing refrigerated propane at atmospheric pressure, these other products can also be stored at reduced expense. For example, butane in tanks similar to those holding propane (less costly since materials need be adequate only for +30° F and far less insulation is required) and natural gasoline can be sub-cooled to a vapor pressure of about 11 to 13 psia and stored in slightly-insulated floating roof tanks. Economic analysis of such multi-product systems must be based upon the operations of a particular plant so no attempt is made here to evaluate returns—the relative advantage outlined in Table 1 is clearly increased when complete multi-product systems are considered.

LITERATURE CITED

[1] Faulkner, C. Shults and Albiol, Ignacio, *Refining Engineer*, April. 1960, p. C-39.

## About the Author

**Dr. John T. Horton** is director and manager of Cryogenic Sales for Chicago Bridge & Iron Company, Chicago. He supervises the design and estimating for refrigerated storage. Horton was an instructor in applied mechanics at Rensselaer Polytechnic Institute in 1952-53 before going with CB&I as a field engineer in 1955. He has been a research engineer and worked on stress analysis and design of nuclear reactor containment vessels and vacuum process vessels. He received B.S. and M.S. degrees from Rensselaer Polytechnic Institute and a Ph.D. from the University of Chicago.

A SPECIAL REPORT

# How to Estimate Fractionating Column Costs

**Using the charts and data given here, you can quickly estimate the complete installed costs of fractionating columns**

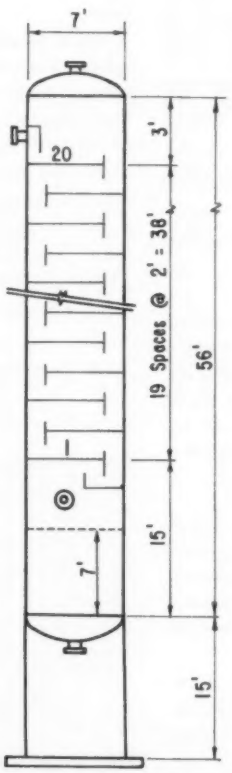
**N. H. Prater and D. W. Antonacci**
The Chemstrand Corporation, Pensacola, Fla.

"DECISION-MAKING" for large expenditures is often made on relatively short notice in the early stages of planning and on the basis of scant knowledge of the conditions under which the ultimate project will be carried out. Obviously, definitive estimates will be prepared prior to final commitments. However, good estimating in the planning stages is equally important if a realistic answer to "how much does it cost" and "what is the rate of return on the investment" is to be presented to Management.

The easiest and probably the most accurate method for arriving at process equipment costs is to obtain quotations from several vendors and arrive at an average price to be used in the estimate, but due to the early stage at which decisions are usually made, the engineer or estimator is not allowed sufficient time to obtain price quotations for the major equipment items. As a result, it is not unreasonable to seek some type of multiplying factor on material cost and apply a per pound price to various vessels and towers of differing complexity.

Arriving at vessel prices in this manner is still making an educated guess since the estimator is not expected to be a vessel expert nor will he have all the data at hand to compensate for complexity, fractionating tray layout, most economical sheet size, etc. However, as a guide in preparing evaluation type estimates, this article presents elementary design and cost factors concerning unit prices of fractionating towers which will allow the estimator to have confidence in the prices and costs of the basic fabricated vessel involved.

The general dimensions of the fractionating tower will usually be specified by the process engineer along with the number and type of trays, materials of construction, corrosion allowance, if used, and the usual external appurtenances. These will include nozzles, manholes, handholes, insulation rings, platforms, ladders and skirt for the support of the vessel. This information is generally transmitted to the estimator in the following form along




| | |
|---|---|
| Item No. | 300-010 |
| Service | Stabilizer |
| Inside Diameter | 7'-0" |
| Length (Tangent To Tangent) | 53'-0" |
| Operating Temperature, °F | 350 |
| Operating Pressure, PSIG | 100 |
| Design Temperature, °F | 400 |
| Design Pressure, PSIG | 120 |
| Corrosion Allowance | None |
| Skirt Height | 15'-0" |

NOZZLES

| No. Required | Size (Inches) | Service |
|---|---|---|
| 1 | 10 | Overhead Vapor |
| 1 | 4 | Relief Valve |
| 1 | 4 | Reflux |
| 2 | 6 | Feed |
| 1 | 12 | Reboiler |
| 1 | 8 | Bottoms |
| 2 | 4 | Level |
| 1 | 2 | Steam Out |

Note: Provide 180° Platforms At 15'-0", 39'-0" And 63'-0"

**FIGURE 1—Design information for the estimator is transmitted on a process vessel sketch similar to the above.**

## COSTS

*Fractionating Column Costs*

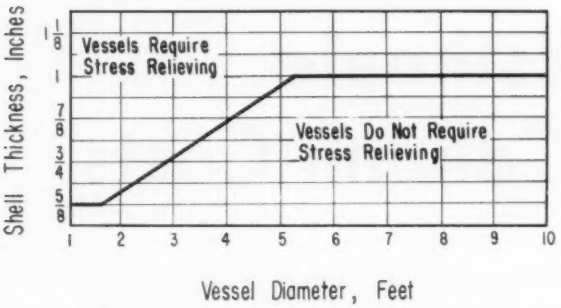



**FIGURE 2—Use this chart as a guide in determining need for stress relieving requirements.**

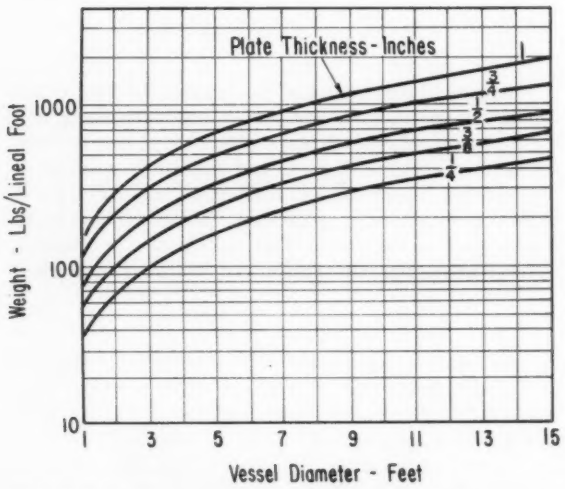



**FIGURE 3—The approximate weight of cylindrical vessel shells can be found from this chart.**

with a simple sketch as shown in Figure 1.

*One-Main Fractionating Tower, EP 300-010:*

7′-0″ x 63′-0″ length (tangent to tangent) column with 20 carbon steel bubble cap trays per the attached sketch shown in Figure 1. Vessel will be constructed of ASTM A-70 Firebox Steel having a thickness of 5/8 inch. No stress relieving or radiographing are required. The tower will be installed as a self-supporting vessel and insulated with 2-inch insulation.

**Shell plates** for fabricated vessels are ordered by thickness and can be obtained in a wide variety of thickness and length although plate widths greater than approximately 8 feet carry an additional width charge and both fabrication procedures and plate costs should be considered in selecting the thickness.[1]

Secondly, stress relieving is usually justified if it reduces the plate thickness by 1/16 inch or more, and radiographing if it reduces the plate thickness by more than 1/8 inch.

There are many design codes governing the construction of pressure vessels and they should be consulted before final designs are prepared. However, the curve shown in Figure 2 can be used as a guide in determining the necessity for stress relieving. For estimating purposes, the curve presented in Figure 3 can be used for determining the weight of tower shells at various plate thicknesses.

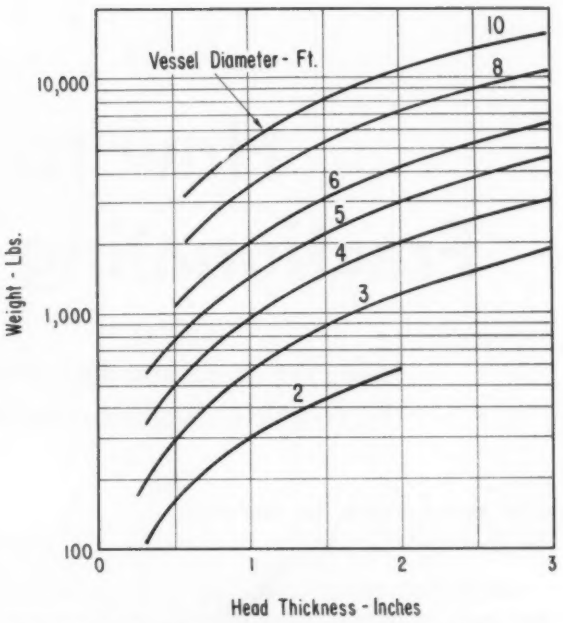



**FIGURE 4—Gives approximate weights of elliptical heads.**

Since economic considerations are the prime factor in selecting alternate materials of construction for specific service conditions, comparative material costs must also be evaluated. As a guide in this type of comparison, approximate base materials costs for carbon steel, alloy and alloy clad materials are included in Table 1. The cladding thickness for alloy material is normally specified as a percentage of the total thickness of the composite plate. The most common thicknesses are 10 percent and 20 percent but thicknesses from 5 percent to 50 percent are obtainable.[2]

**TABLE 1—Comparative Base Price for Carbon Steel, Alloy and Alloy Clad Materials (Cents per Pound)**

| Type of Material | Solid Base Price | 10% Clad Base Price | 20% Solid Base Price |
|---|---|---|---|
| ASTM A-70 Firebox Steel | .8 | .. | .. |
| Type 304 S/S | 55 | 36 | 44 |
| Type 304 S/S, E.L.C. | 62 | 39 | 47 |
| Type 321 S/S | 63 | 38 | 45 |
| Type 347 S/S | 73 | 42 | 51 |
| Type 316 S/S | 80 | 42 | 49 |
| Type 316 S/S, E.L.C. | 87 | 48 | 57 |
| Type 316 S/S, C.B. | 101 | 48 | 58 |
| Nickel | 102 | 47 | 62 |
| Monel | 91 | 49 | 66 |
| ASTM B-168—587 | 100 | 55 | 72 |

NOTE: E.L.C.—Low Carbon Content.
C.B.—Columbium Stabilized.
All stainless & stainless-clad prices include approximately 5 cents per pound charge for annealing and pickling.

**The shop fabrication costs** vary principally with the complexity of the vessel involved and, in general, with vessel size. As a "rule of thumb," shop fabrication costs

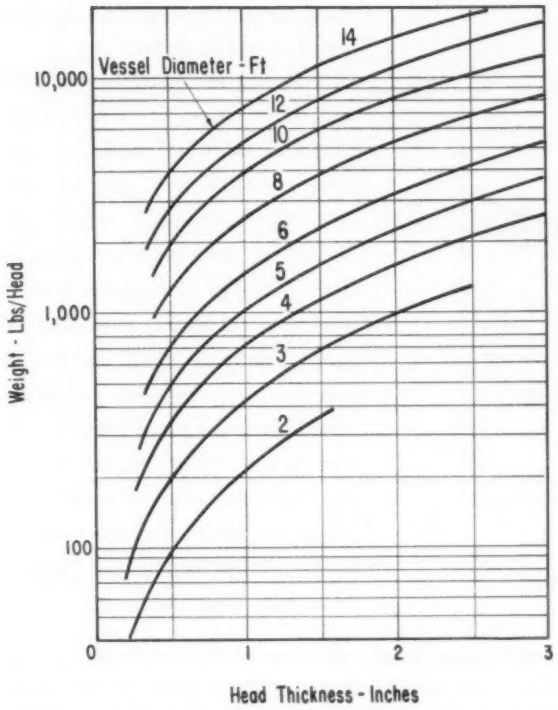



**FIGURE 5—Gives approximate weights of API-ASME flanged and dished heads.**

for the shell sections of towers can be estimated at 25 to 40 cents per pound for carbon steel construction, 50 to 65 cents per pound for alloy construction and 60 to 80 cents per pound for alloy clad materials. The approximate material base price from Table 1 must be added to these costs in arriving at a final sales price.

**Vessel heads** are available in many types for cylindrical vessels. The most common types employed are the flat, elliptical, or API-ASME flanged and dished heads.

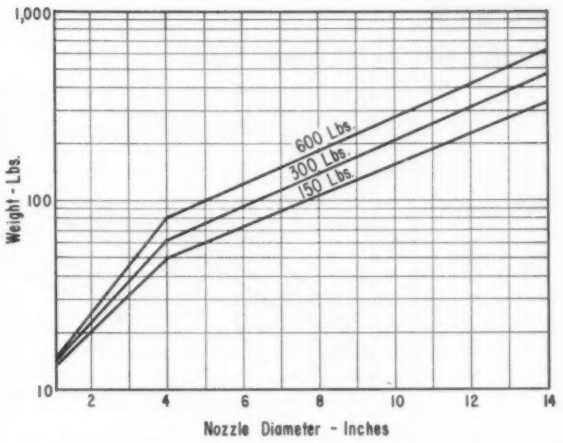



**FIGURE 6—Shows approximate weights of welding neck nozzles for various pressure ratings.**

Flat heads are usually employed only on low pressure vessels under 3 feet in diameter. In general, flanged and dished heads are more economical for operating pressure under 200 psi. Above this pressure, elliptical heads are more economical to use. Both types of heads are manufactured by pressing or spinning large flat plates to the desired shape, however, pressing is generally confined to the smaller size heads and is economical only when large quantities are involved. The weights of both elliptical and flanged and dished heads can be estimated from the curves presented in Figures 4 and 5 respectively. In general, the cost of these heads will vary from 0.35 to 0.60 dollars per pound for carbon steel and 1.25 to 1.70 dollars per pound for Type 304 stainless steel in sizes from 13 feet to 3 feet in diameter.

**Flanges, nozzles and manholes** are selected on the basis of the design rating and design temperature for the

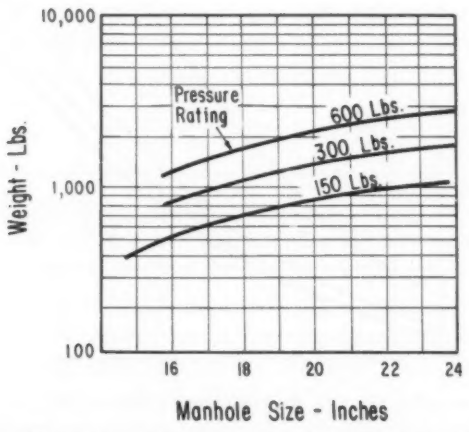



**FIGURE 7—Approximate weights of manholes including cover and davit.**

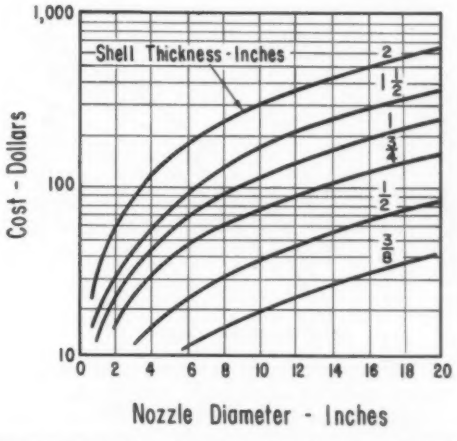



**FIGURE 8—Use this chart for estimating cost for installing carbon steel nozzles in vessel shells for various shell thickness.**

## COSTS

### *Fractionating Column Costs*

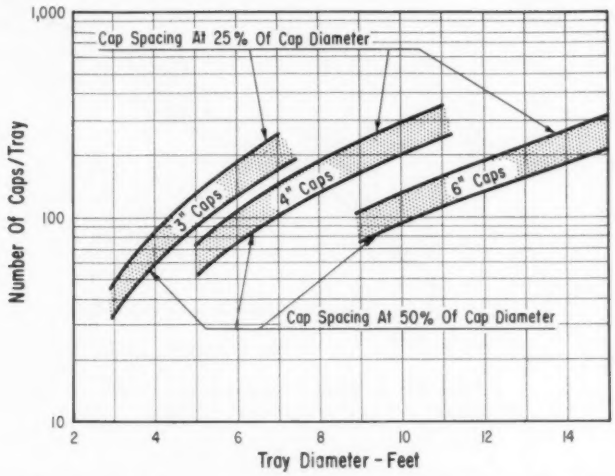



**FIGURE 9—Estimate the total number of bubble caps per tray for various cap sizes and spacing from this chart.**

pressure vessel. These appurtenances may be fabricated of pipe, forged steel nozzles, cast steel, fabricated plate or other suitable material in accordance with the code requirements. The decision whether to use solid, forged, welding-type nozzles or "long welding-necks" depends on relative costs and personal preference. The welding-type nozzles are made with integral reinforcing necks and do not require the additional reinforcement necessary for welding neck nozzles. As an arbitrary guide, slip-on flanges will be used for operating pressure less than 100 psi and welding-neck flanges for pressure above 100 psi. For estimating purposes, the weights of welding neck nozzles can be obtained from Figure 6 and the approximate weights of manholes including the manhole cover from Figure 7 for various pressure ratings. The cost of installing these items can be estimated from Figure 8.

It should be remembered, however, that equipment manufacturers can often fabricate nozzles or manholes cheaper than they can buy commercial ones. For example, an 18 inch manhole rated at 150 psi in Type 304 S/S constructed from a welding-neck flange plus a blind flange costs about $1800 installed. A manufacturers extension and flange with a stainless faced blind flange, also with a 150 pound rating, cost only $600 installed. Therefore the use of the arbitrary selection guide previously outlined should be used as an estimating guide only.

**Bubble-cap trays** and other similar vessel internals for distillation towers are not manufactured by the vessel fabricator and are usually purchased from a manufacturer specializing in these items. Tray supports, however, are provided by the vessel fabricator. A number of completely removable trays are fabricated which can be as-

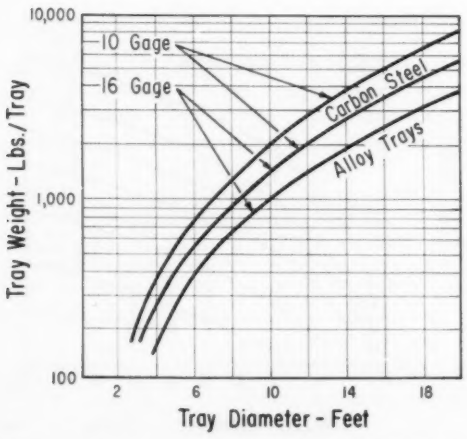



**FIGURE 10—Use these weights for bubble cap trays at 24-inch tray spacing.**

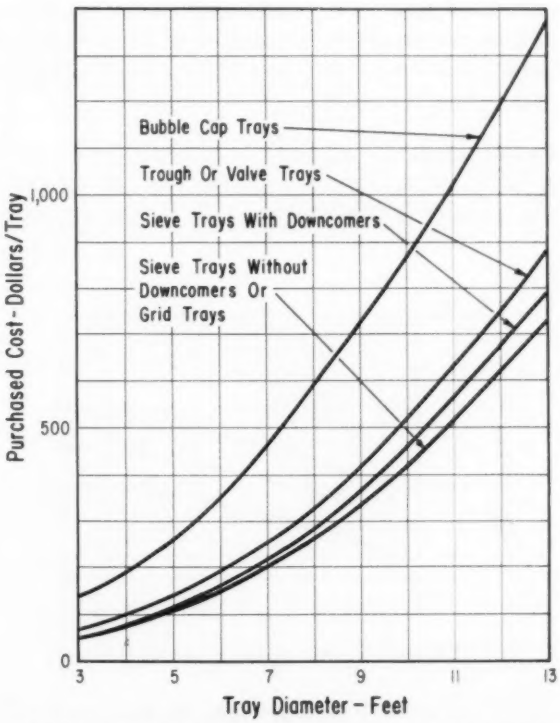



**FIGURE 11—Estimated cost of carbon steel fractionating trays for various types and tower diameters.**

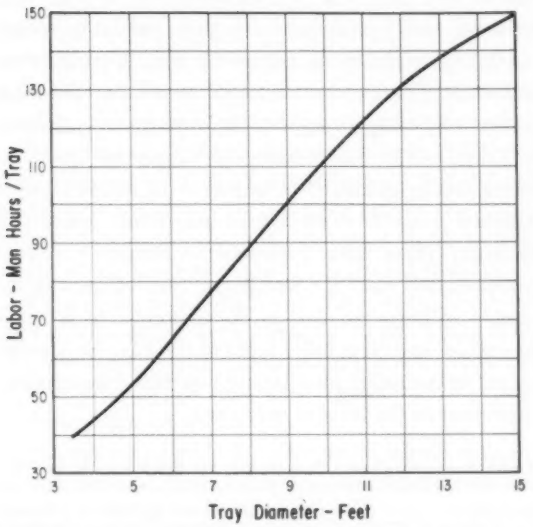



**FIGURE 12—These man hours are for direct field labor for installing bubble cap trays into towers.**

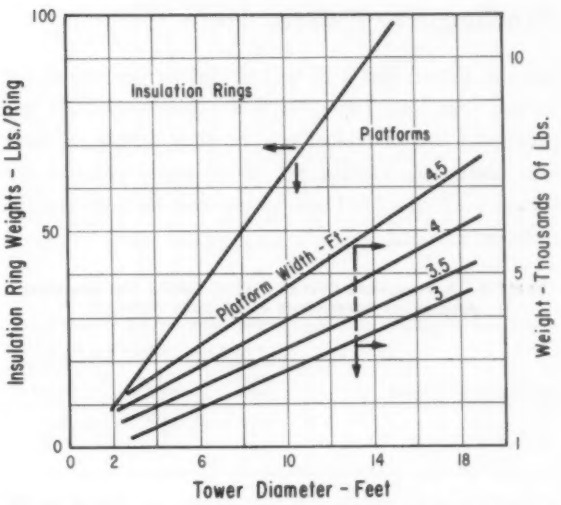



**FIGURE 13—Gives estimated weight of insulation rings and 360-degree platforms including handrails.**

sembled or disassembled within the tower. These trays usually are constructed from stamped or pressed parts of light weight material. The cost of bubble cap trays can vary widely due to the many factors which must be considered in the final tray layout. These include the size, type and number of bubble caps and risers, type and length of downcomers, loading and deflection requirements, quantity and size of the trays, and tray spacing.

As a guide in arriving at basic tray costs, it has been assumed that 3 inch diameter round bubble caps will be used for tray diameters up to and including 5 feet, 4 inch caps for tray diameters from 6 to 10 feet and 6 inch caps for all trays greater than 10 feet in diameter. These caps will have vapor slot areas ranging from 0.035 to 0.11 square feet per cap. Assuming an allocated vapor area of 60 to 70 percent of the tower area, then total slot areas per tray will vary from 10 to 25 percent of the total tray area for cap spacings of 25 to 50 percent of the cap diameter. The selection within these general ranges varies with operating conditions, and practical layout problems. In addition, all trays below 10 feet in diameter are assumed to be single cross flow types and double cross flow is assumed for larger diameter trays to minimize liquid gradients across the tray. In general, a double cross flow tray will cost about 10 percent more than a single cross flow type of the same diameter.

Using these factors as a basis, the total number of bubble caps per tray can be estimated from Figure 9 for various tray diameters and cap spacings. Total weights for the complete tray assembly are shown in Figure 10. The approximate breakdown of these tray weights are: caps and risers 30 percent, tray deck and downcomers 15 percent and tray supports 55 percent. The weight of suitable cap and riser assemblies constructed from light gage materials are shown in Table 2.

**TABLE 2—Approximate Weight of Carbon Steel Bubble Cap and Riser Assemblies**

| Cap Diameter, Inches | Weight of Assembly, Pounds Per Unit | | | |
|---|---|---|---|---|
| | 10 Gage | 12 Gage | 14 Gage | 16 Gage |
| 3 | 2.1 | 1.7 | 1.2 | 1.0 |
| 4 | 3.2 | 2.6 | 1.9 | 1.5 |
| 6 | 4.4 | 3.5 | 2.5 | 2.0 |

The cost of tray supports will vary 0.60 to 0.80 dollars per pound for carbon steel and 1.50 to 1.75 dollars per pound for Type 304 S/S construction. Tray decks and downcomer assemblies can be priced at 0.50 to 0.60 dol-

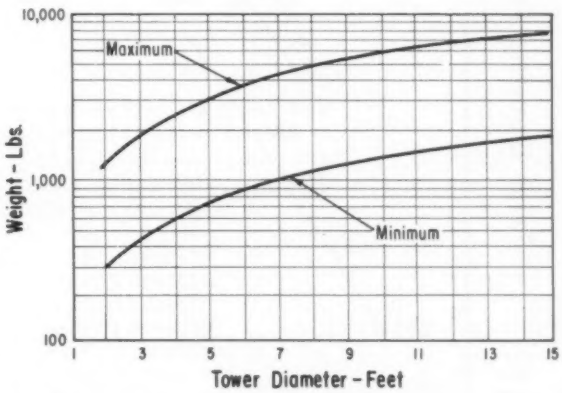



**FIGURE 14—Gives weight of tower support ring including base lugs and stiffeners. Minimum—Assumes ¾-inch base ring thickness and anchor bolt spacing @ 2-foot centers around circumference. Maximum—Assumes 2½-inch base ring thickness and anchor bolt spacing @ 1-foot centers around circumference.**

## COSTS

### *Fractionating Column Costs*

lars per pound and 1.40 to 1.60 dollars per pound for carbon steel and Type 304 S/S respectively. The approximate cost of typical steel or alloy bubble cap and riser assembiles constructed of 16 gage material are shown in Table 3.[3] These values can be adjusted for different material thickness on a weight basis.

**TABLE 3—Approximate Cost of Typical Bubble Cap and Riser Assemblies Constructed of 16 Gage Material**

| Cap Diameter, Inches | Unit Cost, Dollars Per Unit | | |
|---|---|---|---|
| | Carbon Steel | Type 304 S/S | Monel |
| 3 | 1.70 | 3.20 | 4.30 |
| 4 | 1.85 | 4.00 | 5.70 |
| 6 | 2.25 | 5.25 | 7.85 |

The bubble-cap fractionating tray probably enjoys the greatest popularity and has been virtually accepted as the standard type of tray for many years. However, in recent years the sieve tray has gained renewed interest and many new types of unusual tray designs have been developed to challenge the standard bubble-cap tray. The relative merits of the commoner types of tray have been discussed in detail by Katzen[4] and will not be reviewed here. The cost of these new trays and the conventional bubble-cap tray of carbon steel construction can be estimated from Figure 11 for different tower diameters. These costs can be corrected for alloy tray materials by using the appropriate costs factors presented in Table 4. The cost of assembly bubble cap trays into towers can be estimated from Figure 12 where total installation labor in man-hours are shown versus tray diameter. These labor requirements represent average quantities only since the installation time varies with the number of parts required in the assembly. As a guide, the cost for installing other types of trays can be approximated by assuming installations cost will vary in direct proportion to the relative tray costs.

**TABLE 4—Approximate Cost Factors for Alloy Tray Materials**

| Tray Type | 410 S/S | 304 S/S | 316 S/S | Monel |
|---|---|---|---|---|
| Bubble Trays | 1.9 | 2.0 | 2.6 | 3.2 |
| Valve Trays | 1.9 | 2.3 | 2.6 | 4.7 |
| Sieve Trays-with downcomers | 1.9 | 2.4 | 3.3 | 4.2 |
| Sieve Trays-without downcomers | 1.9 | 2.4 | 3.3 | 4.4 |
| Trough Trays | 1.4 | 1.7 | 2.3 | 3.2 |
| Grid Trays | 1.5 | 1.8 | 2.4 | 3.3 |

**External appurtenances** other than nozzles, manholes and handholes must be connected to the average vessel. These include angles for the support of insulation, lugs

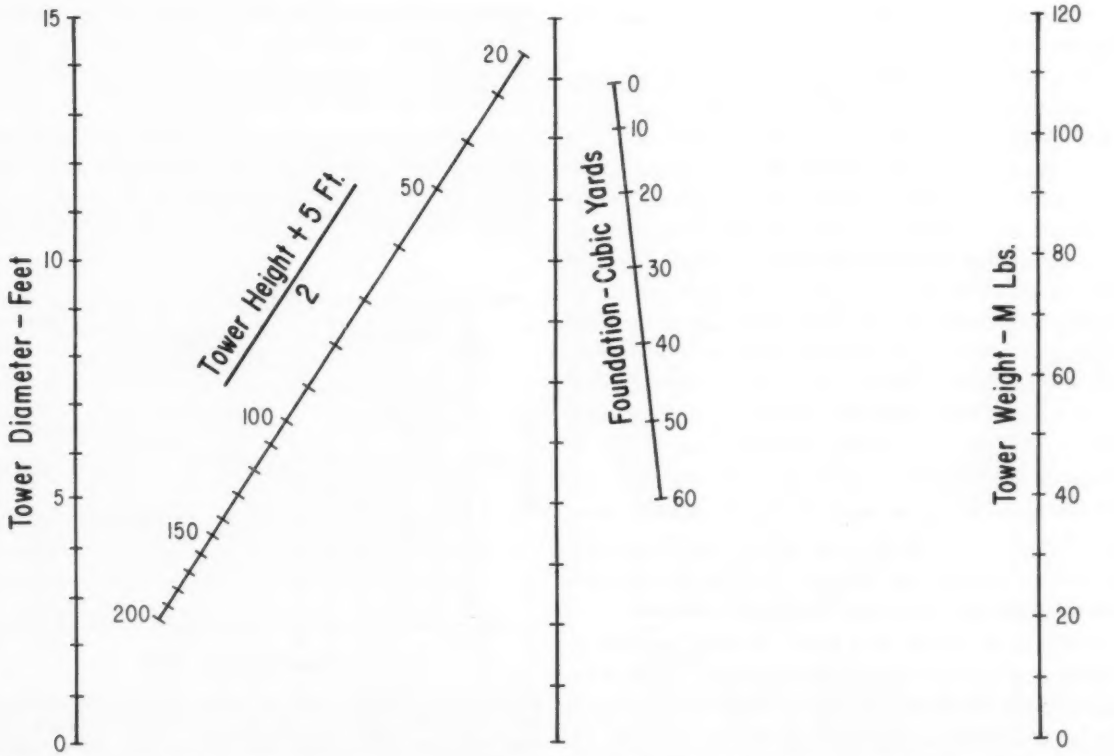



**FIGURE 15—Use this nomogram for estimating foundation concrete requirements based on tower weights and wind forces of about 20 pounds per square foot of projected area. Diameter:height:index - Index:weight:foundation.**

and brackets for the support of platforms and ladders which are to be attached to the vessel, and skirts for the support of the tower at the required elevation. Ladders weights can be approximated at 15 pounds per lineal foot without a cage and 30 pounds per foot where cages are required. Fabrication and erection labor will run approximately 2 to 3.5 man-hours per foot depending upon the necessity for including cages. The weight of 360° full platforms including hand rails and the weight of insulation rings can be estimated from Figure 13 for various tower diameters. In general, insulation rings will be spaced approximately 10 feet apart unless they are incorporated also as stiffening rings. The cost of these items is not great and a figure of 0.30 dollars per pound can be used.

Skirt supports should have the same outside diameter as the vessel shell and attached to the bottom head with a continuous full weld penetration to the vessel head. Skirt base rings must be heavy enough to withstand the compressive loads and stresses subjected by the erected vessel. Normally a double ring base with gusset plates between the upper and lower base ring is employed. The required skirt thickness and skirt support and anchor bolt requirements must be determined by detailed stress analysis calculations before final selection. As an arbitrary guide, the weights of the skirt support including base rings, lugs and gusset plates can be obtained from the curves shown in Figure 14. The minimum curve requirement is based on ¾-inch thick base rings with anchor bolt spacings on approximately 2-foot centers around the circumference of the rings. Conversely, the maximum requirement curve assumes 2½-inch base rings with anchor bolt spacing every foot.

**The foundation size** required for self supporting towers is a function of the combined loads caused by wind, process liquid, vessel equipment and the allowable soil bearing capacity. Foundation requirements may be computed using standard procedures found in many textbooks but for cost estimating purposes the nomograph shown in Figure 15 is usually adequate. The values obtained from the nomograph provide a quick approximation only and were derived assuming a wind force of about 20 pounds per square foot of projected area of the vessel. In determining the projected surface, the vessel diameter should be multiplied by a factor between 1 and 1.5 to allow for ladders, platforms and insulation. The dead loads for the vessel and assocated internals and external appurtenances are derived from the basic factors previously described. Based on asphaltic weatherproof insulation, the insulation will add approximately 4 pounds per square foot of vessel surface for the first inch of insulation thickness and about 1 pound for each additional inch.[5] The estimated vessel surface area can be obtained from Figure 16 for various vessel diameters.

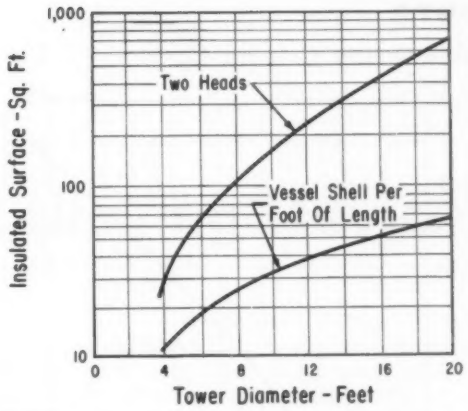



**FIGURE 16—Total surface for insulation can be picked off this chart.**

**Field labor** for the installation of the vessel should be arrived at by carefully studying the layout and including, therefore, all necessary costs including direct supervision and labor, crane or rigging equipment rentals, leveling and final testing. Consideration must also be given to the number of vessels to be set, their proximity to one another, degree of congestion in the area and the spcific equipment that can be utilized without duplication of costs. Since these specific details are usually not available when preparing evaluation type estimates, the direct field labor and equivalent equipment hours may be estimated using the data shown in Figure 17. Equivalent equipment hours are derived by dividing the equipment rental cost by the prevailing wage scale for skilled riggers.

The above principles and cost factors are briefly illustrated in the following example using the complete tower shown in Figure 1. The cost of the complete tower assembly will be estimated on a price per pound basis. For simplicity all external appurtenances will be included in the vessel cost.

## EXAMPLE

**Method A—Price Per Pound Basis:**

**1. Weight of Tower Assembly**

| | | |
|---|---|---|
| Vessel Shell from Figure 3: 500#/ft. x 56 ft. | = | 28,000 # |
| Vessel Heads from Figure 5: 1200#/head x 2 | = | 2,400 |
| Nozzles from Figure 6: | | |
| (a) 2″ 1 x 20 | = | 20 |
| (b) 4″ 4 x 50 | = | 200 |
| (c) 6″ 1 x 72 | = | 72 |
| (d) 8″ 1 x 110 | = | 110 |
| (e) 10″ 1 x 160 | = | 160 |
| (f) 12″ 1 x 225 | = | 225 |
| Manholes from Figure 7: 3x 650 | = | 1,950 |
| Vessel Skirt from Figure 3: 500#/ft. x 15 ft. | = | 7,500 |
| Bubble Cap Trays from Figure 10: 850#/Trays x 20 Trays | = | 17,000 |
| Insulation Rings from Figure 13: 3 x 45 | = | 135 |
| 180° Platforms, 4′ wide from Figure 13: 3 x 3200 x 0.5 | = | 4,800 |

## COSTS

*Fractionating Column Costs*

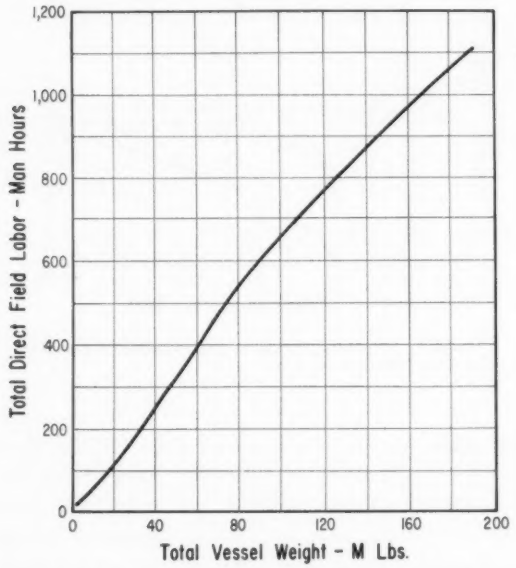



**FIGURE 17—Gives estimated field labor man hours for tower erection. Equivalent equipment hours are derived by dividing the equipment rental cost by the prevailing wage scale for skilled riggers.**

| | |
|---|---|
| Support Rings and Base Lugs from Figure 14: 1 x 2000 | = 2,000 |
| Ladders with Cages: 30#/ft. x 70 ft. | = 2,100 |
| TOTAL ESTIMATED WEIGHT OF COMPLETE TOWER ASSEMBLY | = 66,672# |

**2. Purchased Cost of Complete Tower Assembly**

| | |
|---|---|
| Material Cost: 66,672# x 1.1 x $0.08/# | = $ 5,867 |
| Total Fabrication Labor: 66,672# x 4 Manhours/100# x $3.50/hr. | = 9,334 |
| Total Fitting & Assembly Labor: 66,672 x 1.25 Manhours/100# x $3.50/hr. | = 2,917 |
| Drafting Time: 100 Manhours x $3.00/hr. | = 300 |
| TOTAL DIRECT LABOR COST | = $12,551 |
| Shop Burden @ 100% of Direct Labor Cost | 12,551 |
| Total Shop Cost | $25,102 |
| General Office Overhead @ 12% of Shop Cost | 3,012 |
| Total Manufacturing Cost | 28,114 |
| Profit @ 10% of Manufacturing Cost | 2,811 |

SUMMARY OF COSTS:

| | |
|---|---|
| Material Cost | $ 5,860 |
| Manufacturing Cost | 28,114 |
| Profit | 2,811 |
| Total Sales Price | $36,785 |
| COST PER POUND | $ 0.55 |

**Method B—Simplified Cost Per Pound Basis:**

| | |
|---|---|
| Total Weight of Tower Assembly without Trays | = 49,672# |
| Vessel Cost: 49,672# x $0.55/# | = $27,300 |
| Cost of Bubble Trays from Figure 11: 20 trays @ $485/tray | = 9,300 |
| Total Cost | = $36,600 |

**3. Cost of Installing Bubble Cap Trays**

| | |
|---|---|
| A. From Figure 12: 75 Manhours/tray x 20 trays x $4.10/hr. | = $ 6,150 |
| B. Labor Rates: 65% Boilermakers @ $3.75/hr. | = $ 2.44 |
| 35% Laborers @ $2.50/hr. | = 0.88 |
| | $ 3.32 |
| Supervision @ 20% | 0.80 |
| | $ 4.12/hr. |

**4. Foundation Cost**

| | |
|---|---|
| A. Weight of erected vessel: | |
| 1) Weight of complete tower assembly | = 66,672# |
| 2) Weight of Insulation: | |
| Area of two heads from Figure 16 | = 90 sq.ft. |
| Area of tower shell from Figure 16: 21 sq.ft./linear ft. x 56 ft. | = 117 sq.ft. |
| Total Insulated Area | = 207 sq.ft. |
| Insulation Weight: 5#/sq.ft. x 207 sq.ft. | = 1,035# |
| 3) Weight of Connecting Piping (Assumed) | = 5,000# |
| Total Weight of Empty Vessel | = 72,707# |

The total quantity of concrete required for the tower foundation can be approximated from the nomograph shown in Figure 15. The tower diameter will be increased by a factor of 1.3 to allow for ladders, platforms, nozzles, etc. On this basis, a tower diameter of 9 feet will be used. Total vessel height to be used is estimated at $(56' + 15' + 5')/2 = 38$ feet. Using these approximations, total concrete requirements for the foundation is 9 cubic yards. The total foundation cost including excavation, forming, concrete, reinforcing steel, etc. will run about $60 per cubic yard or a total cost of $560.

**5. Tower Erection Cost.** Erection costs will be estimated on a weight basis. For this purpose, the vessel weight to be used will include the weight of the complete tower assembly less trays and insulation. On this basis, the total weight of the vessel to be erected is assumed to be 49,672#. From Figure 17, the total direct field labor will be approximately 330 manhours. Figuring total labor at an hourly rate of $4.00 per hour, then the erection cost will run about $1,320.

**Summary of Total Installed Cost**

| | |
|---|---|
| Cost of Complete Tower Assembly | = $36,785 |
| Freight (assumed @ $3 per 100#) | = 2,000 |
| Cost of Installing Bubble Trays | = 6,150 |
| Cost of Foundation | = 560 |
| Cost of Tower Erection | = 1,320 |
| Cost of Misc. Field Materials (platform, scaffolding, dead men, etc.) @ 15% of total direct field labor | = 1,250 |
| Cost of Insulation (approx. $2.25/sq.ft.) | = 465 |
| TOTAL DIRECT INSTALLED COST | = $48,530 |

No charges have been added for overheads since these costs will vary between companies and geographical locations, however, these charges must be included in the final erected cost figures.

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[1] Thiesinger, W. G., "Fabrication Costs of Boilers, Tanks and Pressure Vessels as Affected by Plate Widths," Lukens Steel Co.

[2] "Clad Steel Equipment," Lukens Steel Co. Publication.

[3] Zimmerman and Lavine, "Chemical Engineering Costs," Ind. Research Service, Dover, N.H., 1950.

[4] Katzen, R., "Help in Picking the Right Tray," *Chemical Engineering*, Nov., 1955, p. 209.

[5] Turner, D. R., "Basic Guide to Pressure Vessel Design—5," *Oil and Gas Equipment*, August, 1956.

*Design tips for . . .*

# Piping of Pressure Relieving Devices

**Pressure safety valves and safety discs must 'fail safe.' Engineered approaches to piping and support design are essential for reliability**

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THE MOST important design factor about pressure relieving devices is the underlying principle of intrinsic safety. They must "fail safe" or not at all. Therefore, the solution to problems in pressure relief piping must be based on sound design practices. Because failure is intolerable, simplicity and directness of design should be encouraged as a means to reliability.

There are at least four good reasons why the installation of pressure safety valves and discs should be engineered with care: (1) The inlet and outlet piping can reduce the capacity of the device below a safe value. (2) The operation of the device may be adversely affected to the point where the opening or closing pressure is altered. In the case of safety valves,* premature leaking or "simmering" may occur at pressures less than the set pressure or chattering may occur after the valve opens. (3) The reaction thrust at the time the device starts to discharge can cause mechanical failure of the piping. (4) Good design saves maintenance dollars.

**Safety Valve Inlet Piping.** In order to operate satisfactorily, a safety valve must be mounted vertically. It should be directly on the vessel nozzle or on a short connection fitting that provides direct and unobstructed flow between the vessel and the valve. Safety valves protecting piping systems should of course be mounted in a similar manner. The device may never be installed on a fitting having a smaller inside diameter than the safety valve inlet connection. Horizontal vessel nozzles, when used for safety valve mounting, may be connected as in Figure 1.

**Pressure Drop.** The pressure drop between the vessel and safety valve inlet flange should not be so large that the valve is "starved" or chattering will result. Sylvander and Katz[1] suggest the following limitations:

- The pressure drop due to friction should not exceed 1 percent of the accumulated relieving pressure.
- The pressure drop due to velocity head loss should not exceed 2 percent of the accumulated relieving pressure.

Some safety valve manufacturers suggest a maximum total pressure drop of 2 percent of set pressure. In the absence of test data, it is recommended that this more conservative limit be used.

These recommendations are based on a blowdown of 4 percent. Within limits, if the blowdown setting is increased, the pressure drop may be increased proportionately. Remember however that pressure lost in the inlet piping must be taken into consideration when sizing the safety valve.

**Overstressed Piping.** It is important that the inlet piping or mounting nozzle on the vessel not be overstressed. The reaction force at the time of valve opening, along with the forces transmitted from the discharge piping must be considered. To minimize strain from these sources, keep the inlet piping as short as possible. Consider these remedies for troublesome situations:

- Stiffen the nozzle with gusset plates.
- Use a long welding neck nozzle cut to proper length. This will provide added stiffness without sacrifice of internal area, since the long welding neck nozzle has a greater section modulus than does the same nominal size pipe.
- Use an oversized nozzle and reducer.
- Orient line-mounted valves to discharge in a direction parallel to the line upon which they are mounted. This method is useful when the thrust would overtorque the main upon which the valve is mounted, or cause excessive deflection. The lever arm and consequently the moment may be reduced by this method. Also bracing is handled more simply.

Safety disc-safety valve combinations may occur where the disc outlet is larger than the safety valve inlet. This arrangement (using a reducer) is satisfactory as long as the assembly is strong enough mechanically.

**Block Valves.** Locked-open or sealed-open block valves are sometimes specified in relief lines for maintenance purposes. These valves should be full area gate or plug type. Gate valves should be of the rising-stem type. The wedge disc should be so connected to the stem that disengagement is highly improb-

* For sake of brevity, the term "safety valve" will be used throughout this article to describe relief valves, safety valves, and safety-relief valves.

able. The valve should be located so that the gate moves horizontally. Plug valves should be constructed so that the direction of opening is readily visible and unmistakable.

Where three-way valves are employed to direct the flow to or from alternate safety relief devices, the valve selected must provide full-area opening at all valve positions. The transflow valve is of this type. Where block valves of this style are used on both inlet and outlet piping, they must be so connected that it is impossible to operate one valve without simultaneously operating the other. The only exception allowed is when the valves are locked or sealed in position. The key, in this case, must be held by a responsible supervisor.

**Low temperature service,** below 32° F, may cause atmospheric moisture to condense on the valve seat and freeze. One method which will prevent this is to install the safety device with an uninsulated vertical inlet line. This line must be sufficiently long to create a dead space which is adequate to insulate the safety device from the low process operating temperatures. The valve must not be allowed to reach a temperature below the dew point of the atmosphere. Consider the fact that a small leak may exist through a safety valve seat. If the warming section of inlet piping does not provide sufficient protection against freezing, it may be necessary to heat the valve by steam tracing or other appropriate means. The designer is cautioned that when the inlet line is lengthened it is usually necessary to brace the line to prevent overstressing by the large bending moments which occur at the time of discharge.

**Plugging** tendencies in the inlet piping due to coking, salting, congealing, etc., may demand special designs. Consider heating, insulating, purging, flushing or blanketing the device, whichever is suitable. Figure 2 shows one type of seal which is useful to isolate the valve from the process fluid.

**Safety Valve Discharge Piping.** The back-pressure permitted on a safety valve depends on several factors. One of these is the valve's back-pressure rating. This is not necessarily the same as the ASA rating of the outlet flange, but must be obtained from the manufacturer. Conventional safety valves discharging either to atmosphere or to any other constant pressure cannot tolerate a build-up or rise in back-pressure greater than 10 percent of the net spring setting (spring set pressure with discharge at atmospheric pressure). Even though the back-pressure is constant it must always be at least 5 psi lower than the pressure at which the valve is set to open.

## *Inlet piping design . . .*

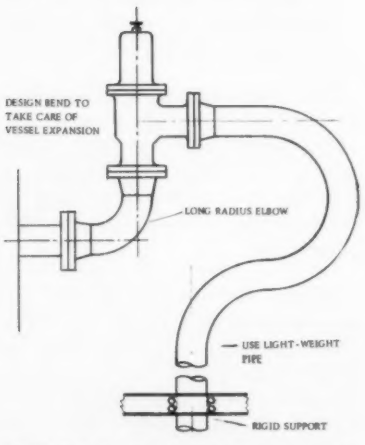


**FIGURE 1—Horizontal vessel nozzles, when used for safety valve mounting, can be connected this way.**

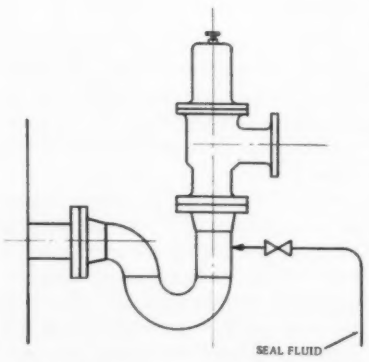


**FIGURE 2—Valve can be isolated from process fluid this way.**

**Balanced bellows valves** operate practically independent of back-pressure up to pressures as high as 80 percent of the inlet pressure. They are limited principally by the mechanical strength of the valve and bellows as established by the manufacturer's rating.

Of course it must be recognized that the above limitations are exclusive of the effect of back-pressure on valve capacity. If the drop across the valve orifice falls below the critical pressure ratio the valve capacity must be calculated on the basis of sub-sonic flow.

**Piping Guide.** Various factors determine the type of discharge piping arrangement that should be used. Table 1 is a guide to the selection of a suitable design based on considerations which are frequently involved.

**Hazardous Fluids.** Figure 3 should not be used on hazardous fluids unless the valve is at a considerably higher elevation than the surrounding equipment and the discharge can be directed away from such equipment. The possible need for a bird screen should be considered.

When hazardous fluids are discharged from valves installed as in Figure 4, the terminal point should be at least 10 feet above any walkways which are within a 25 foot radius.

**Drain Hole Plug.** The safety valve drain hole plug (Figure 4) should be removed in those services where liquid could gather at the valve discharge. This includes services where condensate may form or where rain or snow may enter the discharge pipe and collect as a liquid in the line. If the plug is removed, the drain hole must be piped for safe disposal if the fluid is hazardous or if the location of the hole is such that sudden discharge through the opening might endanger personnel. If the pipe is not warm enough to melt any snow which may enter it, a cover must be provided. This may be either a lid as shown in Figure 10 or a light plastic bag fastened around the end of the pipe. Metal covers in some sizes are also available commercially.

**Flashing liquids,** wherein much of the liquid is vaporized on relieving, should not be emptied to a sewer or other ground location without

# Table 1—Design Guide for Discharge Piping

| Service | FIGURE NUMBER: Valve Indoors | FIGURE NUMBER: Valve Outdoors |
|---|---|---|
| **Non-Hazardous Service —(a)** | | |
| Air or Gas | 3,(b) 4,(b) 7 | 3,(b) 4(b) |
| Liquid | 5 | 5 |
| Steam or Vapor | | |
| Discharge Pipe Size to 1" | 6 | 6 |
| Discharge Pipe Size to 1½"—2½" | 4 | 4 |
| Discharge Pipe Size to 3 Inches and over | 7 | 4 |
| **Hazardous Service —(a)** | | |
| Closed system (to vent stack, burning stack or scrubber) | 8 | 8 |
| Open system (to atmosphere) | | |
| Gas—(c) | 3, 4 | 3, 4 |
| Liquid—(d) | 5 | 5 |
| Vapor—(c)(d) | 3, 4, 6 | 3, 4, 6 |
| Pyrophoric Gases or Vapor—(e) | 9 | 9 |

**Low Temperature Service**

At or below ambient—design discharge pipe so that now or ice cannot accumulate at any point in the line where the temperature may be at or below freezing. Use Figure 3, if possible. Where necessary Figure 4 may be used with a cover.

Below 32° F—locate safety valve to avoid need for discharge piping, if possible. Discharge opening and exposed spring must be protected from the weather. A housing or local heating may be required. The discharge, if properly designed, may be sealed with a low viscosity oil and covered with plastic to prevent the entrance of moisture.

**Notes:**

(a) Flammable or toxic fluids are considered hazardous.

(b) Discharge pipe not required if outlet over 7 feet above walkway and/or directed away from personnel.

(c) Carry discharge outdoors to a safe elevation.

(d) Carry to an appropriate drain.

(e) Point of discharge must be safe for fire.

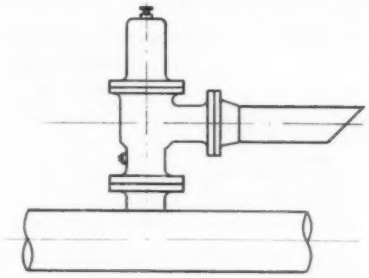

**FIGURE 3—For air or gas service.**

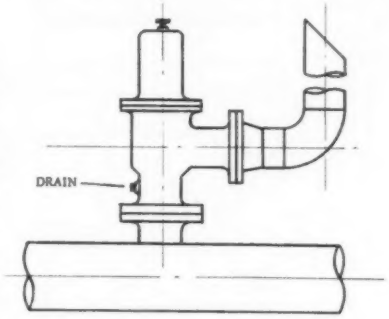


**FIGURE 4—For air, gas or steam service.**

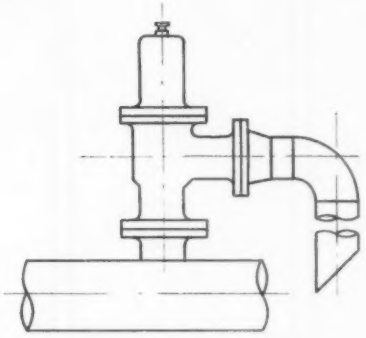

**FIGURE 5—For liquid service.**

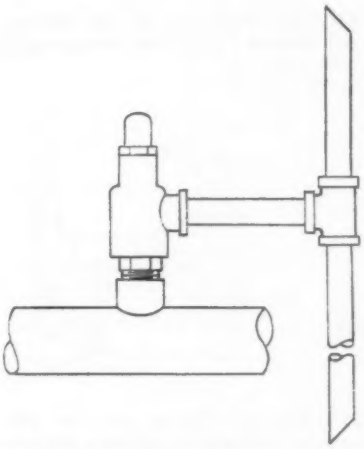

**FIGURE 6—For steam or vapor service.**

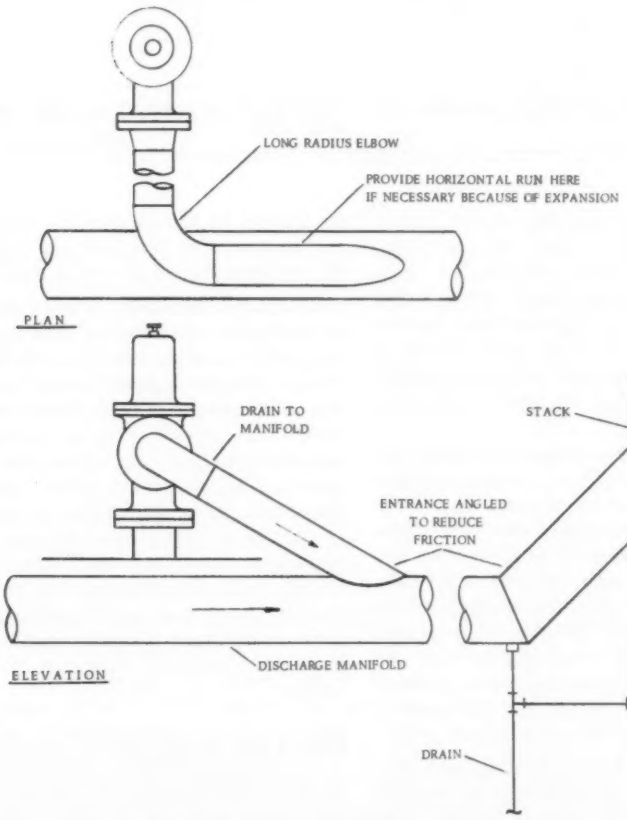


**FIGURE 8—Closed system for hazardous service.**

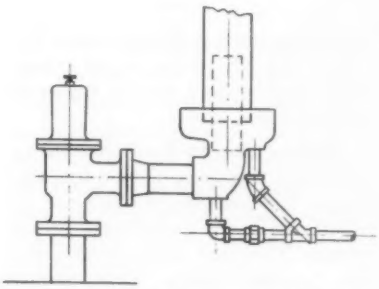

**FIGURE 7—For steam or vapor service to 3 inch pipe.**

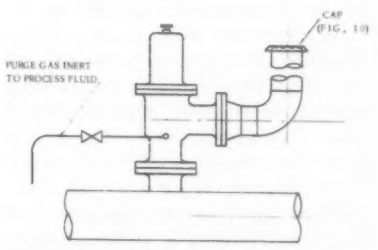


**FIGURE 9—Open system for pyrophoric gases.**

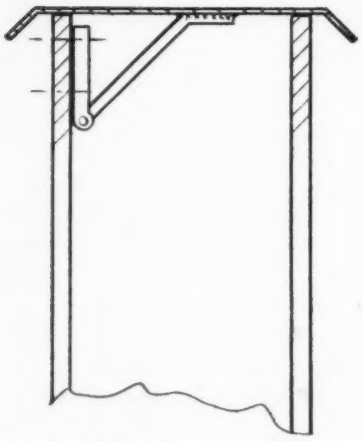

FIGURE 10—A cap like this will protect discharge pipe from being plugged with snow.

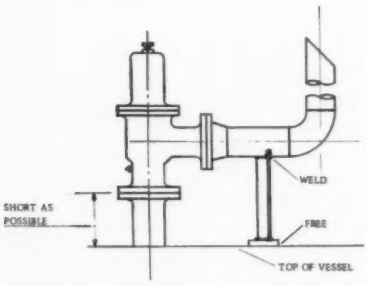


FIGURE 11—Piping must be adequately anchored to prevent sway or vibration while the valve is discharging.

## Table 2—Safety Disc Piping

| Service | FIGURE NUMBER Single Disc. | Double Disc. |
|---|---|---|
| Discharge to Atmosphere | | |
| Outdoors, light weight ass'y.—(a) | 12 | 15 |
| Outdoors, heavy ass'y.—(b) | 13, 14 | 16 |
| Indoors—(c) | 14 | 16 |
| Closed system | 17 | 17 |

**Notes:**
(a) Parts of assembly 100 lbs. or less for ease of handling.
(b) Parts of assembly exceed 100 lbs. and require mechanical lifting.
(c) Vent stack through roof.

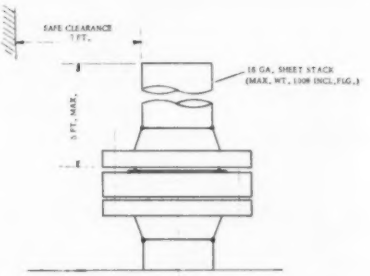


FIGURE 12—For lightweight assembly.

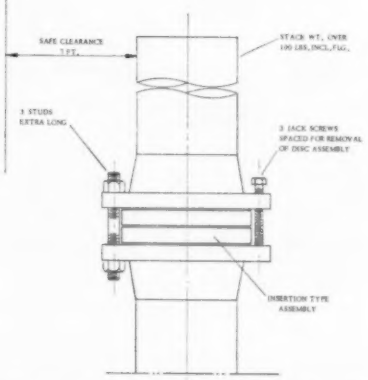
SAFE CLEARANCE 1 FT.
STACK WT. UNDER 100 LBS. INCL. FLG.
3 STUDS EXTRA LONG
3 JACK SCREWS SPACED FOR REMOVAL OF DISC ASSEMBLY
INSERTION TYPE ASSEMBLY

FIGURE 13—For heavy assembly with short stack.

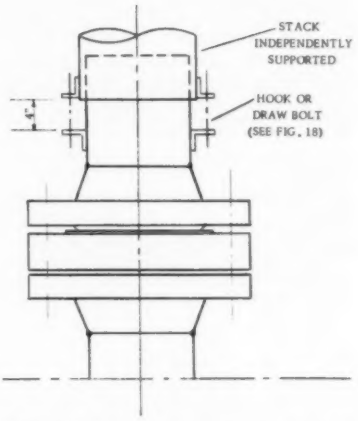


FIGURE 14—For heavy assembly with long stack.

proper protection for personnel. The vapor will propel the liquid at high velocity and may spatter passersby with the hot liquid.

**Piping Supports.** Safety valves, although they may not be included under the heading of "delicate instruments," are nonetheless instruments. They are required to measure pressure within three percent and to perform a specific control function. Excessive strain on the valve body adversely affects its ability to measure and control.

Supports for discharge piping should be designed to keep the load on the valve to a minimum. In high temperature service, high loads will cause permanent distortion of the valve because of creep in the metal. Even at low temperatures, valve distortion will cause the valve to leak at pressures lower than the set pressure and result in faulty operation. The discharge piping should be supported free of the valve and carefully aligned so that the forces acting on the valve will be at a minimum when the equipment is under normal operating conditions. Expansion joints or long radius bends of proper design and cold spring should be provided to prevent excessive strain.

The major stresses to which the discharge pipe is subjected are usually due to thermal expansion and discharge reaction forces. The sudden release of a compressible fluid into a multi-directional discharge pipe produces an impact load and bourdon effect at each change of direction. The piping must be adequately anchored to prevent sway or vibration while the valve is discharging (Figures 1 and 11).

**Pressure loss** in the discharge piping should be minimized by running the line as directly as possible. Use long-radius bends and avoid close-up fittings. In no case may the cross-sectional area of the discharge pipe be less than that of the valve outlet.

**Discharge Manifolds.** The design of discharge manifolds or vent systems with multiple safety valves involves numerous factors which have not been considered here. Optimum design will depend upon an overall economic study of the system composed of vessels, safety valves, and discharge piping. Increasing certain vessel design pressures or changing certain safety valves to the balanced bellows type may decrease the discharge piping cost significantly. A study of this type is rather complex and is beyond the scope of this article.

**Piping For Safety Discs.** Some of the problems associated with the installation of the safety disc are similar to those of the safety valve; some are entirely different. For instance,

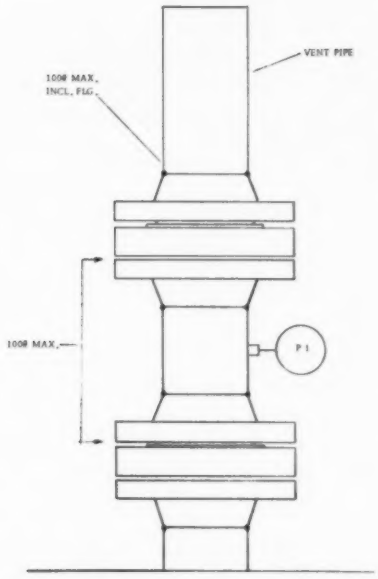


FIGURE 15—Double disc with light-weight assembly.

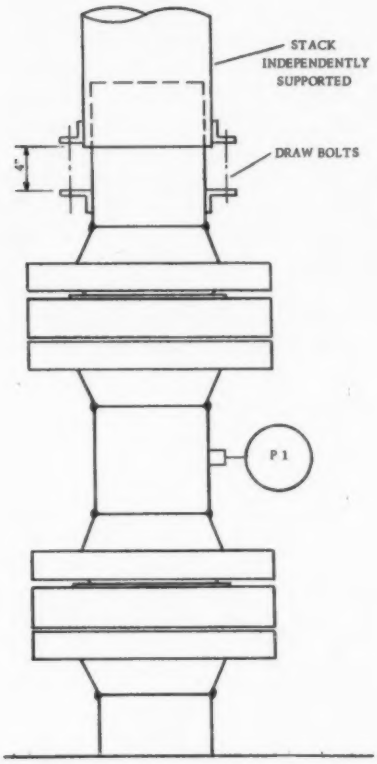


FIGURE 16—Double disc with heavy assembly.

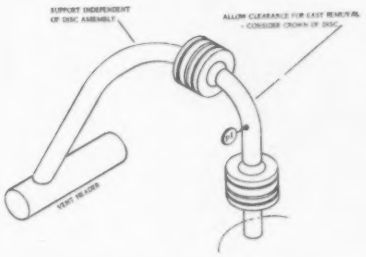

FIGURE 17—Closed system.

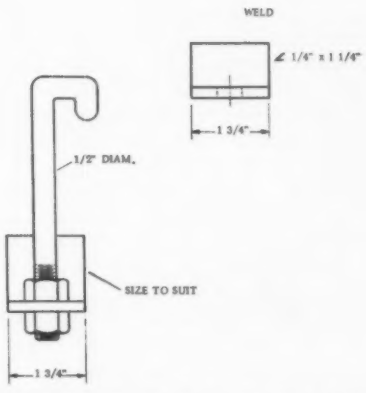


FIGURE 18—Hook detail (Draw-bolt similar).

the use of block valves in conjunction with a safety disc calls for the same design practices recommended for the safety valve. Protection against plugged inlets, freezing, drainage of the outlet and handling of flashing liquids requires similar treatment. Stack covers must be provided.

Since the safety disc has no moving parts it is not as sensitive to overstressing as is the safety valve. However, care must be used in bolting up the assembly so that the diaphragm is not reduced in cross-section or damaged in any other way by high or uneven flange pressure.

**Outlet Piping.** The size of outlet piping required for a safety disc is not necessarily the same as the disc receptacle size. Discs are frequently sized on the basis of pressure requirements rather than capacity requirements. In such cases it is possible for the outlet piping to be smaller than the pipe size of the disc receptacle. If an arrangement of this type is desirable, the pipe diameter must be calculated on the basis of the relief capacity requirements and the maximum allowable upstream pressure. The inlet piping, however, must have an area which is at least equal to that of the receptacle in order to comply with the ASME code.

**Pressure Drop.** The pressure drop allowed through the inlet and discharge lines is unlimited as long as the capacity of the line is adequate for the relief requirements. That is, at the required flow rate the vessel pressure must not exceed the maximum allowable accumulated pressure. In sizing a safety disc, it is usually assumed that the entrance loss at the nozzle is the governing restriction insofar as capacity is concerned. Thus the effective orifice area is considerably larger than the effective orifice area of a safety valve of the same pipe size. Consequently, the pressure loss in the piping will be of greater importance in the case of the disc. It is advisable to check the effect of line pressure drop on any safety disc installation with a low rupture pressure or a long discharge line.

The allowable pressure loss through the discharge pipe, exclusive of the entrance loss, may be determined as follows:

$$P \leq P_a r_c$$

where, $P_a$ = Accumulated relieving pressure, psia

$P$ = Pressure inside relief pipe near the vessel, psia

$r_c$ = Critical pressure ratio for sonic velocity

$$= \left(\frac{2}{k+1}\right)^{k/(k-1)}$$

(See values of $r_c$ tabulated below)

k = ratio of specific heats

If P exceeds $P_a r_c$ it becomes necessary to size the safety disc based on subsonic flow.

**Back Pressure.** The pressure limitations referred to above apply only to built-up pressure necessary to expel the fluid through the discharge piping after the disc has ruptured. Back-pressure which is present before the disc ruptures is another matter, since it affects the rupture pressure. If the back-pressure is constant, the rupture pressure must be specified based on the difference between the maximum safe vessel pressure and the back-pressure. If the back-pressure is variable as is the case when several pressure relief devices discharge into a common header, it cannot be allowed to increase by more than 10 percent of the maximum allowable working pressure. Discharge to pressures less than atmospheric is acceptable, but the disc rating may not be increased to compensate for the added pressure difference because failure of the vacuum would prevent the disc from rupturing at the pressure specified by the vessel code.

Of course if the equipment being protected is not covered by the vessel code, the limitations cited are not mandatory. The ASA Code for Petroleum Refinery Piping, for instance, permits temporary conditions of overpressure.

**Disc Replacement.** The considerations involved in the design of a safety disc installation are similar to those which were discussed under safety valves. In addition, the design features of the piping should reflect the need for periodic disc replacement. Changing a disc should be an operation which is quick, easy, and as safe as possible. Access platforms should be provided where necessary.

**Piping Guide.** Table 2 is a guide to various types of piping designs recommended for safety discs.

**Reaction Forces.** The total stress imposed on a safety valve or its piping is caused by the sum of these forces: (a) internal pressure, (b) dead weight of piping, (c) thermal expansion or contraction of either the discharge line or the equipment upon which the valve is mounted, and (d) the bending moment caused by the reaction thrust at the discharge. All of these stresses except the latter are common to practically every problem in piping stress analysis and will not be covered here. The magnitude of the reaction force resulting from the instantaneous release of a compressible fluid may be calculated from the two simple formulas given below.

For a safety valve . . .

$$F_1 = (k + 0.2)\, AP_1$$

For a safety disc . . .

$$F_1 = 0.63\,(k + 0.2)\, AP_1$$

Where:

$F_1$ = Reaction force, lbs.

A = Area of value orifice or disc, sq. in.

$P_1$ = Inlet pressure at time of opening, psia (set pressure plus 14.7)

k = Ratio of specific heats, $c_p/c_v$

## About the Author

**L. R. Driskell** is the principal instrument engineer for the Blaw-Knox Co., Chemical Plants Division, Pittsburgh. The Instrument Department, which he heads, is not only responsible for all instrumentation but establishes the design pressure and temperature ratings of all pressure equipment, vessels, piping and designs the safety relief systems. Driskell has been with Blaw-Knox for 12 years. He has worked in the instrument and pressure vessel field for 20 years, having previously been associated with E. I. du Pont de Nemours & Co., Inc., and J. E. Segram & Sons, Inc. He is also chairman of the Final Control Elements Committee of the Instrument Society of America. This committee is responsible for all technical activity of the society with respect to pressure safety valves and safety discs.

If it is possible for air to be relieved from the system under special conditions, use a minimum value of k = 1.4 for design.

Calculation of the reaction force for liquid service demonstrates that this force is negligible. However, since it is usually possible to trap air or gas in any pressure system it is recommended that k = 1.4 be used in the above formulas as a basis of piping design for liquid service.

Here are values of k which can be safely used for common fluids:

| Fluids | k | $r_c$ |
|---|---|---|
| Air and diatomic gases | 1.4 | 0.53 |
| Steam | 1.3 | 0.55 |
| $NH_3$, $CO_2$, $CH_4$ and $SO_2$ Vapors | 1.3 | 0.55 |
| Helium, Argon | 1.67 | 0.49 |

**Vacuum Breakers.** Vacuum breakers are used on pressure vessels to prevent their collapse should the internal pressure be allowed below that of the atmosphere. Their installation offers few problems. They should be installed with a minimum of pipe since the pressure drop limitations are invariably stringent. Bird screens are usually required.

The admission of air to some processes may be more hazardous than the collapse of the vessel. The problem cannot be overcome by merely supplying the vessel with inert gas through a pressure reducing valve. Neither the reducing valve nor the source of gas is sufficiently reliable. The best solution is to design the vessel for full vacuum. If a number of vessels are involved it may be economical to connect them to an inert gas system which floats on a gas holder. All valves should be locked open and the gas holder should be equipped with a low level alarm. Another method which has been used on very large vessels is to provide two separate sources of inert gas. These independent pressurizing systems are then each equipped with alarms to warn the operator when safety depends upon a single system.

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[2] API RP 520, *Recommended Practice for the Design and Construction of Pressure-Relieving Systems in Refineries*, (Sept. 1955).

[3] ASME Boiler and Pressure Vessel Code Section VIII, (1959).

[4] Crocker, Sabin, *Piping Handbook*, McGraw-Hill, (1945).

# Applied Hydrocarbon Thermodynamics

## Part 19: Generalized Correlation of Fugacity Coefficients for Hydrocarbon Mixture Components

**Wayne C. Edmister**
Oklahoma State University, Stillwater

EMPIRICAL GENERALIZED correlations were recently[1] developed for the liquid and vapor phase fugacity coefficients of hydrocarbon mixture components. These correlations gave the values of the fugacity coefficients ($\bar{f}_i^V/Py_i$) and ($\bar{f}_i^L/P_i^\circ x_i$) as functions of reduced temperature, $T_r$, the reduced pressure, $P_r$, and the boiling point ratio, $B_r$. The work was based on the published fugacities from the equation of state computations by the Benedict-Webb-Rubin Equation-of-State for 12 light hydrocarbons at pressures up to 3,600 psia.

Use of the three generalized parameters ($T_r$, $P_r$, and $B_r$) permitted combining all the calculated fugacity data into a master generalized correlation for each phase. The resulting correlations were greatly consolidated by the use of an intermediate "equivalent" temperature parameter, which is a function of reduced temperature and the boiling point ratio. This work is described and the generalized charts presented in this part.

**Introduction.** Fugacities, partial volumes, partial entrophies, and partial enthalpies are related. The actual values of these thermodynamic properties for each hydrocarbon depend upon the temperature and pressure conditions and upon the system composition. For multicomponent systems, this can be very complicated; so that it is desirable to simplify with short cuts which give reasonably accurate results.

In the past, such simplifications have not always been adequate, so that the results of processing calculations based upon them have not been sufficiently accurate. Prior to 1932, the vapor-liquid equilibria phase distribution calculations for hydrocarbon systems were frequently made by the use of vapor pressures, and heat balances were made by the use of average heat capacities for liquid and vapor and approximate heats of vaporization for the mixture. During the past twenty years, the thermodynamic tools for such process engineering calculations have been improving gradually so that now methods are available for estimating the temperature, pressure, and composition effects on the vapor-liquid equilibria and the enthalpy for hydrocarbon systems.

The object of this work was to develop a generalized correlation of the fugacity coefficients of components in hydrocarbon vapor and liquid mixtures. Such a correlation would permit the extension of phase equilibria estimates to other components and conditions and the calculation of consistent values for the other partial thermodynamic properties.

**Fugacity Coefficients and "K" Values.** As previously pointed out, coexisting liquid and vapor phases are in equilibrium when the pressure and temperature of the two phases are equal and when the fugacity values of each component are the same in each phase, i.e., $\bar{f}^L = \bar{f}^V$. Components designating subscripts will be omitted from the equations for simplicity in some of the equations.

The K values of each component is defined as the ratio of the mole fraction of that component in the vapor phase to the mole fraction in the liquid phase, i.e., $K = y/x$. In terms of fugacity coefficients, i.e., ratio of fugacity to mole fraction, the K value is

$$K = \frac{y}{x} = \frac{\bar{f}^L/x}{\bar{f}^V/y} \qquad (19.1)$$

The fugacity coefficients, which have the dimensions of pressure, can be calculated from pressure-volume-temperature-composition data on mixtures by the application of thermodynamic relations and an equation of state. Experimental vapor liquid equilibria measurements give values of y and x and not fugacity coefficients.

For correlation purposes, Equation 19.1 was written

$$K_i = \frac{y_i}{x_i} = \frac{\bar{f}_i^L/P_i^\circ x_i}{\bar{f}_i^V/Py_i} \frac{P_i^\circ}{P} \qquad (19.2)$$

where:

$P_i^\circ$ = vapor pressure of any component
$P$ = total pressure

Note: This installment is based on a paper by Edmister and Ruby, CEP, February 1955.

$P_i^\circ/P$ = Raoult's Law K-value
$f_i^L/P_i^\circ x_i$ = fugacity coefficient of any component in liquid phase
$f_i^V/Py_i$ = fugacity coefficient of any component in vapor phase

The denominators of these two fugacity coefficients are the standard states of reference. At system temperatures above the critical, an extrapolated vapor pressure must be used.

This choice of standard state is justified by the resulting correlation. It seems logical and convenient because the ratio of these fugacity coefficients is a correction to the simple Raoult's Law K-value.

**Previous Correlations.** Generalized correlations of thermodynamic properties have been useful chemical engineering tools for the past two decades. By using reduced pressures ($P/P_c$) and temperatures ($T/T_c$), pressure-volume-temperature (P-V-T) data for pure hydrocarbon systems have been correlated. From these generalized compressibility factor and residual volume correlations, the isothermal effects of pressure on the enthalpy and entropy and the fugacity coefficients have been derived and correlated for pure component systems but these methods have not been adequate for nonideal mixtures.

The simultaneous estimation of K values and thermodynamic properties requires the use of more basic thermodynamic methods, such as an empirical equation of state fitted to experimental pressure-volume-temperature-composition data and then applied to the computations of the thermodynamic properties.

Benedict et al[2] developed such an empirical equation of state and computed vapor activity and liquid fugacity coefficients for 12 light hydrocarbons under pressure up to 3,600 pounds per square inch.

Because of the large number of composition possibilities presented by 12 components, these authors selected molal average boiling point of the phase in question as the composition variable. This was admitted to be a compromise between precision and practicality, but the results would have been unwieldy otherwise. With this simplification, several series of fugacity calculations were made for selected binary hydrocarbon systems in such a way as to simulate all possible mixtures of the 12 hydrocarbons. By selecting binary systems, the assumption was made that the balance of the mixture, other than the component in question, could be treated as a single average hypothetical component. This is an approximation which was justified by the results.

After calculating these binary system fugacity coefficients, the results were correlated as a function of temperature, pressure, and molal average boiling point of the phase in question. Thus, composition effect was handled by the average boiling point of the phase, an empirical approximation limited to the paraffinic and olefinic hydrocarbon systems covered.

The original charts[3] were plots of fugacity coefficients against temperature. These were replotted and published by the M. W. Kellogg Company in 1950.[4] Publication was in two parts, one containing 144 charts of K values with correction factors for pressures up to 1,000 psi and the other containing 132 charts of fugacity coefficients for pressures from 1,000 to 3,600 psi.

The atmospheric to 1,000 psi Kellogg charts were replotted and improved by De Priester[5] with three objectives: (a) to reduce the number of charts required; (b) to facilitate pressure interpolations; and (c) to improve the accuracy in some ranges. These pressure-temperature-composition charts were in the form of two-parameter charts, one for the liquid phase and one for the vapor phase, for each hydrocarbon, thus condensing 144 charts to 24 with improved accuracy. Additional experimental "K" data were used in the preparation of these charts.

In a parallel and independent project, Canjar and Edmister[6] computed partial enthalpy values for six light hydrocarbons from the first temperature derivatives of the fugacity and activity coefficients from the original Polyco charts.[3] The partial enthalpy differences thus

**TABLE 19.1—Values of P° for Liquid Phase Fugacity Coefficient PSIA**

| °F | $CH_4$ | $C_2H_4$ | $C_2H_6$ | $C_3H_6$ | $C_3H_8$ | $iC_4H_8$ | $iC_4H_{10}$ | $nC_4H_{10}$ | $iC_5H_{12}$ | $nC_5H_{12}$ | $nC_6H_{14}$ | $nC_7H_{16}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| —100 | 866.6 | 65.33 | 31.31 | 3.853 | 2.887 | 0.388 | 0.547 | 0.276 | ..... | ..... | ..... | ..... |
| — 80 | 1135 | 101.0 | 50.37 | 7.21 | 5.48 | 0.860 | 1.171 | 0.625 | ..... | ..... | ..... | ..... |
| — 60 | 1451 | 149.5 | 77.29 | 12.55 | 9.68 | 1.739 | 2.295 | 12.85 | 0.296 | 0.179 | ..... | ..... |
| — 40 | 1809 | 213.1 | 113.9 | 20.61 | 16.16 | 3.249 | 4.17 | 2.439 | 0.622 | 0.392 | ..... | ..... |
| — 20 | 2212 | 294.3 | 161.8 | 31.94 | 25.30 | 5.684 | 7.12 | 4.326 | 1.205 | 0.789 | 0.15 | ..... |
| 0 | 2657 | 395.1 | 223.2 | 47.64 | 38.11 | 9.404 | 11.53 | 7.25 | 2.182 | 1.475 | 0.311 | ..... |
| 20 | 3143 | 517.5 | 299.7 | 68.76 | 55.46 | 14.90 | 17.86 | 11.56 | 3.726 | 2.594 | 0.606 | ..... |
| 40 | 3668 | 663.3 | 393.0 | 96.32 | 78.30 | 22.34 | 26.41 | 17.69 | 6.05 | 4.325 | 1.107 | 0.288 |
| 60 | 4232 | 834.3 | 504.7 | 131.5 | 107.6 | 32.45 | 37.89 | 25.90 | 9.42 | 6.887 | 1.911 | 0.541 |
| 80 | 4829 | 1031 | 635.2 | 175.5 | 144.6 | 45.85 | 52.93 | 36.87 | 14.10 | 10.54 | 3.143 | 0.960 |
| 100 | 5461 | 1256 | 789.1 | 229.3 | 190.3 | 63.22 | 72.19 | 51.18 | 20.40 | 15.63 | 4.956 | 1.620 |
| 120 | 6120 | 1510 | 963.8 | 294.3 | 245.6 | 85.23 | 96.34 | 69.45 | 28.54 | 22.20 | 7.531 | 2.616 |
| 140 | 6810 | 1791 | 1162 | 371.3 | 311.6 | 112.7 | 126.2 | 92.37 | 39.04 | 30.82 | 11.075 | 4.065 |
| 160 | 7523 | 2102 | 1385 | 461.5 | 389.3 | 146.3 | 162.4 | 120.6 | 52.34 | 41.90 | 15.89 | 6.106 |
| 180 | 8260 | 2443 | 1631 | 565.9 | 479.7 | 186.8 | 205.7 | 154.8 | 67.35 | 55.88 | 21.93 | 8.899 |
| 200 | 9029 | 2813 | 1902 | 685.7 | 583.5 | 235.2 | 256.8 | 195.7 | 89.21 | 73.21 | 29.69 | 12.62 |
| 220 | 9797 | 3213 | 2199 | 821.2 | 702.0 | 291.8 | 316.6 | 244.2 | 113.7 | 94.43 | 39.49 | 17.45 |
| 240 | 10,590 | 3642 | 2521 | 973.4 | 835.4 | 358.0 | 385.6 | 300.7 | 143.0 | 120.0 | 51.69 | 23.47 |
| 260 | 11,400 | 4099 | 2868 | 1143 | 984.7 | 434.0 | 464.5 | 366.1 | 177.5 | 150.5 | 66.61 | 31.08 |
| 280 | 12,230 | 4583 | 3241 | 1330 | 1150 | 520.7 | 554.0 | 441.0 | 217.9 | 186.5 | 84.68 | 40.52 |
| 300 | 13,050 | 5097 | 3638 | 1537 | 1332 | 618.9 | 654.5 | 526.0 | 264.4 | 228.5 | 106.3 | 52.08 |
| 320 | 13,900 | 5635 | 4060 | 1761 | 1533 | 729.0 | 766.8 | 621.8 | 317.9 | 277.0 | 131.9 | 66.10 |
| 340 | 14,750 | 6200 | 4506 | 2005 | 1751 | 851.7 | 891.3 | 728.8 | 378.6 | 332.7 | 161.9 | 82.88 |
| 360 | 15,610 | 6790 | 4975 | 2269 | 1986 | 987.7 | 1028 | 847.7 | 447.1 | 395.8 | 196.8 | 102.8 |
| 380 | 16,470 | 7403 | 5469 | 2552 | 2241 | 1137 | 1179 | 979.0 | 523.7 | 467.3 | 237.0 | 126.3 |
| 400 | 17,340 | 8041 | 5984 | 2854 | 2513 | 1300 | 1342 | 1123 | 609.1 | 547.3 | 283.0 | 153.5 |

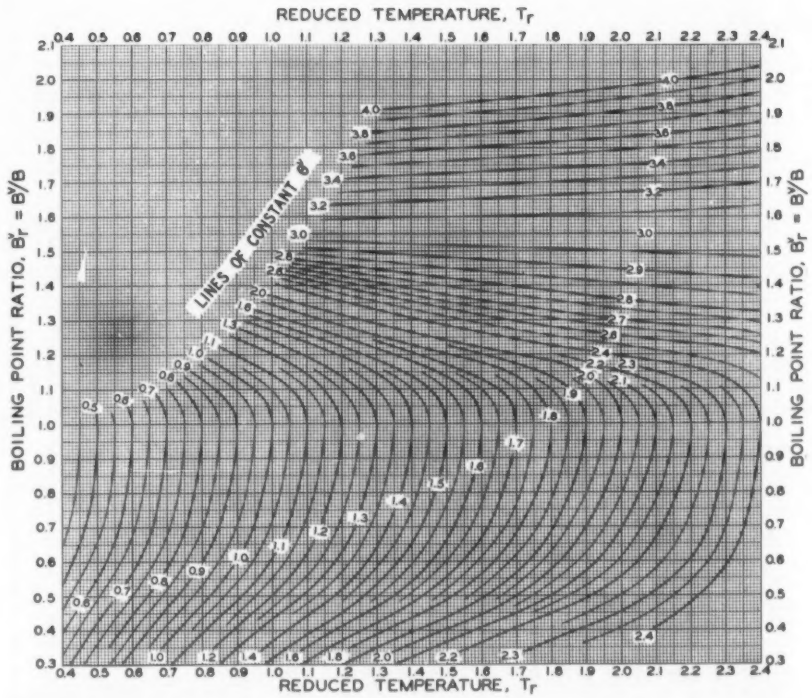
REDUCED TEMPERATURE, $T_r$
BOILING POINT RATIO, $B'_r = B'/B$
LINES OF CONSTANT $\theta'$
REDUCED TEMPERATURE, $T_r$
BOILING POINT RATIO, $B'_r = B'/B$

FIGURE 19.1—Generalized temperature—composition function hydrocarbon vapors.

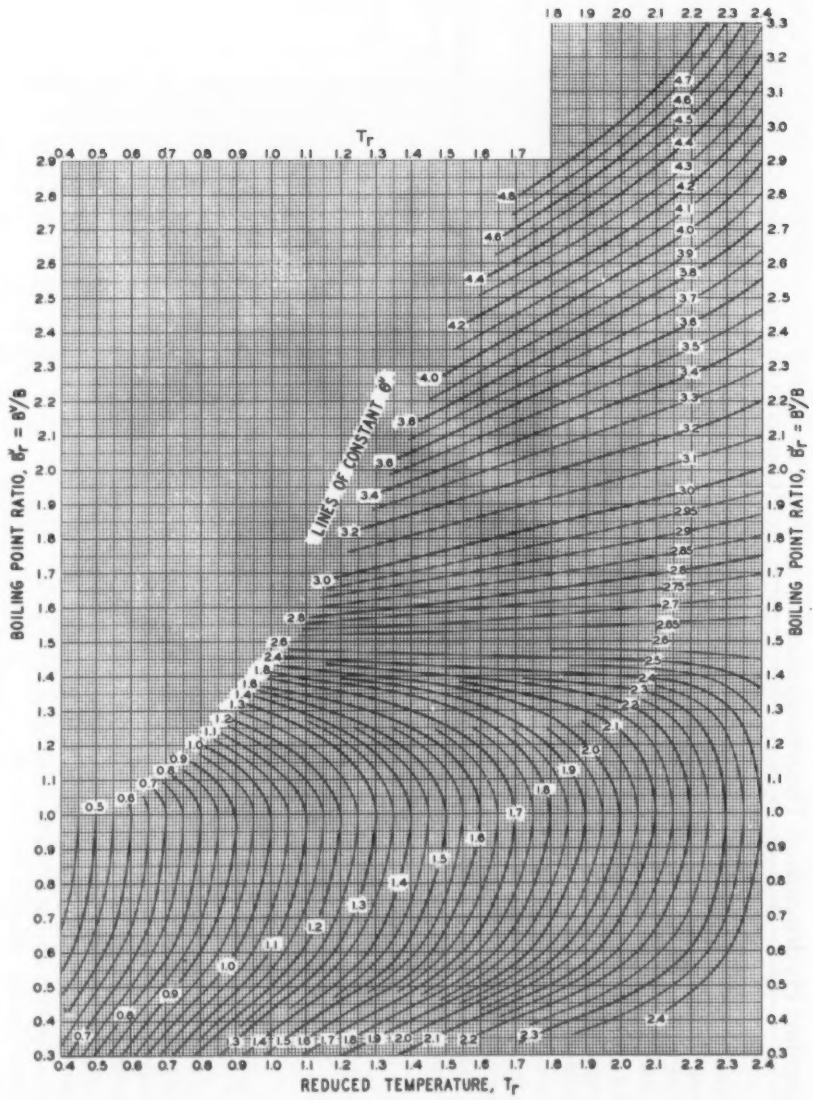


FIGURE 19.2—Generalized temperature—composition function methane vapor (right).

obtained were combined into a generalized correlation using reduced temperature and pressure and a boiling point ratio as the parameters.

Boiling point ratio, which is the parameter that handled the composition effect, is the ratio of the molal average atmosphmeric boiling point of the phase to the atmospheric boiling point of the component. Thus, this ratio, like the reduced temperature and pressure, has a system property in the numerator and a component property in the denominator.

The three reduced parameters found successful in this generalized partial enthalpy correlation are

$$T_{ri} = \frac{T}{T_{ci}} = \frac{\text{System temperature, °R}}{\text{Critical temperature of } i^{th} \text{ component, °R}}$$

$$P_{ri} = \frac{P}{P_{ci}} = \frac{\text{System pressure, lb/sq.in.abs.}}{\text{Critical pressure of } i^{th} \text{ component, lb/sq.in.abs.}}$$

$$B_{ri} = \frac{B}{B_i} = \frac{\text{M.A.B.P. of vapor or liquid-phase mixture, °R}}{\text{Atmospheric boiling point of } i^{th} \text{ component, °R}}$$

For any set of equilibrium conditions, the first two ratios will be the same in both liquid and vapor phase for any component, while the third will differ for the two phases. The value of $B_r$ will range from less than unity to greater than unity for each phase. $B_r = 1.0$ for a pure (or single) component system. $B_r$ is also unity for the component having a boiling point equal to the molal average boiling point of the mixture.

These parameters were also used in developing the generalized activity coefficient correlations.

**Data for Correlations.** From the original Polyco[3] charts of the Benedict et al[2] work, smoothed values of $\bar{f}/x$ and $\bar{f}/Py$ were read and the parameters converted to reduced units. Two-way interpolations were then made to get values of $\bar{f}/x$ and $\bar{f}/Py$ at even 0.1 intervals of $T_r$ and $B_r$. This was done as described below.

A total of 31,000 points was taken for the two phases of the 12 hydrocarbons (methane, ethylene, ethane, propylene, propane, isobutylene, isobutane, *n*-butane, isopentane, *n*-pentane, *n*-hexane, and *n*-heptane) at 11 of the 18 pressures (50, 200, 400, 600, 800, 1,000, 1,400, 1,800, 2,200, 2,800, and 3,600 psi) and 11 of the 16 molal average boiling points (—255, —240, —210, —150, —60, 0, +60, 120, 150, and 180° F) for which plots were available. Readings were made at 20° F system temperature intervals to facilitate interpolations.

These data were punched on computing machine cards from which reduced conditions (i.e., $T_r$, $P_r$, and $B_r$) were computed. Typwritten tapes giving the $\bar{f}/Py$ and $\bar{f}/x$ values and the corresponding reduced parameters were printed from the cards containing these results. These were later used in checking the precision of the correlations.

Two-way interpolations were next made to get values of $\bar{f}/x$ and $\bar{f}/Py$ at even 0.1 intervals of $T_r$ and $B_r$.

**TABLE 19.2—Deviations of Generalized Fugacity Coefficients from Benedict (Polyco) Values**

| Hydrocarbon | LIQUID PHASE | | VAPOR PHASE | |
|---|---|---|---|---|
| | Abs. Percent Deviation | No. of Points | Abs. Percent Deviation | No. of Points |
| Methane | 5.0 | 67 | 2.1 | 97 |
| Ethylene | 3.0 | 78 | 2.6 | 125 |
| Ethane | 3.1 | 60 | 2.4 | 98 |
| Propylene | 3.8 | 40 | 1.8 | 58 |
| Propane | 3.2 | 40 | 2.2 | 73 |
| *i*-Butylene | 3.4 | 61 | 4.2 | 70 |
| *i*-Butane | 3.8 | 36 | 4.3 | 57 |
| *n*-Butane | 4.1 | 40 | 4.2 | 72 |
| *i*-Pentane | 4.2 | 62 | 4.9 | 60 |
| *n*-Pentane | 5.3 | 33 | 6.9 | 62 |
| *n*-Hexane | 5.2 | 55 | 7.5 | 60 |
| *n*-Heptane | 5.2 | 52 | 6.6 | 50 |
| Totals | 4.1 | 624 | 3.8 | 882 |

**TABLE 19.3—Literature Data Sources of K-Values**

| Components | Pressure From | Pressure To | Temperature From | Temperature To | No. of Points | Source |
|---|---|---|---|---|---|---|
| **1. Binary Systems** | | | | | | |
| Methane | 100 | 600 | —201 | +16 | 14 | 8 |
| Ethane | 100 | 600 | —201 | +16 | 11 | .. |
| Ethane | 100 | 500 | 0 | 225 | 6 | 9 |
| *n*-Butane | 100 | 500 | 0 | 225 | 6 | .. |
| Ethane | 200 | 800 | 275 | 350 | 2 | 10 |
| *n*-Heptane | 200 | 800 | 275 | 350 | 2 | .. |
| Methane | 200 | 700 | 100 | 220 | 6 | 11 |
| *i*-Butane | 200 | 700 | 100 | 220 | 6 | .. |
| Methane | 60 | 800 | 70 | 220 | 6 | 12 |
| *n*-Butane | 60 | 800 | 70 | 220 | 6 | .. |
| Methane | 20 | 800 | 100 | 340 | 5 | 13 |
| *n*-Pentane | 20 | 800 | 100 | 340 | 5 | .. |
| *n*-Pentane | 147 | 445 | 285 | 447 | 6 | 14 |
| *n*-Heptane | 147 | 445 | 285 | 447 | 6 | .. |
| Propane | 200 | 620 | 125 | 260 | 6 | 15 |
| *i*-Butylene | 200 | 620 | 125 | 260 | 6 | .. |
| Methane | 200 | 800 | 70 | 160 | 5 | 16 |
| Propane | 200 | 800 | 70 | 160 | 6 | .. |
| Propylene | 70 | 340 | 25.5 | 135 | 9 | 17 |
| Propane | 70 | 340 | 25.5 | 135 | 9 | .. |
| Ethylene | 57 | 255 | —100 | 100 | 10 | 18 |
| Ethane | 57 | 255 | —100 | 100 | 10 | .. |
| **2. De Priester Multicomponent Systems** | | | | | | |
| Methane | 100 | 800 | — 60 | 300 | 26 | 5 |
| Ethane | 100 | 800 | — 60 | 300 | 29 | .. |
| Propane | 100 | 800 | — 60 | 300 | 28 | .. |
| *i*-Butane | 100 | 800 | — 60 | 300 | 6 | .. |
| *n*-Butane | 100 | 800 | — 60 | 300 | 19 | .. |
| *n*-Pentane | 100 | 800 | — 60 | 300 | 7 | .. |
| *n*-Heptane | 100 | 800 | — 60 | 300 | 1 | .. |
| 2, 2, 4-Trimethylpentane | 100 | 800 | — 60 | 300 | 1 | .. |
| *n*-Decane | 100 | 800 | — 60 | 300 | 1 | .. |
| **3. Other Multicomponent Systems** | | | | | | |
| Methane | 2055 | 3485 | 40 | 200 | 4 | 19 |
| Ethane | 2055 | 3485 | 40 | 200 | 4 | .. |
| Propane | 2055 | 3485 | 40 | 200 | 4 | .. |
| Methane | 500 | 1000 | 100 | 160 | 4 | 20 |
| Ethylene | 500 | 1000 | 100 | 160 | 4 | .. |
| *i*-Butylene | 500 | 1000 | 100 | 160 | 4 | .. |
| Methane | 500 | 1000 | 100 | ... | 2 | 21 |
| Ethane | 500 | 1000 | 100 | ... | 2 | .. |
| *n*-Pentane | 500 | 1000 | 100 | ... | 2 | .. |
| Methane | 500 | 1000 | 100 | ... | 2 | 22 |
| Propane | 500 | 1000 | 100 | ... | 2 | .. |
| *n*-Pentane | 500 | 1000 | 100 | ... | 2 | .. |
| Methane | 500 | 1000 | 160 | 220 | 4 | 23 |
| Propane | 500 | 1000 | 160 | 220 | 4 | .. |
| *n*-Pentane | 500 | 1000 | 160 | 220 | 4 | .. |
| Methane | 1000 | .... | 160 | ... | 1 | 24 |
| *n*-Butane | 1000 | .... | 160 | ... | 1 | .. |
| *n*-Decane | 1000 | .... | 160 | ... | 1 | .. |
| Methane | 1000 | .... | 280 | ... | 1 | 25 |
| *n*-Butane | 1000 | .... | 280 | ... | 1 | .. |
| *n*-Decane | 1000 | .... | 280 | ... | 1 | .. |
| Methane | 517 | 1736 | 100 | ... | 4 | 26 |
| Ethane | 517 | 1736 | 100 | ... | 4 | .. |
| Propane | 517 | 1736 | 100 | ... | 4 | .. |
| *n*-Butane | 517 | 1736 | 100 | ... | 4 | .. |
| *n*-Pentane | 517 | 1736 | 100 | ... | 4 | .. |
| Methane | 1046 | 1419 | 100 | ... | 2 | 26 |
| Ethane | 1046 | 1419 | 100 | ... | 2 | .. |
| Propane | 1046 | 1419 | 100 | ... | 2 | .. |
| *n*-Pentane | 1046 | 1419 | 100 | ... | 0 | .. |
| *n*-Hexane | 1046 | 1419 | 100 | ... | 1 | .. |

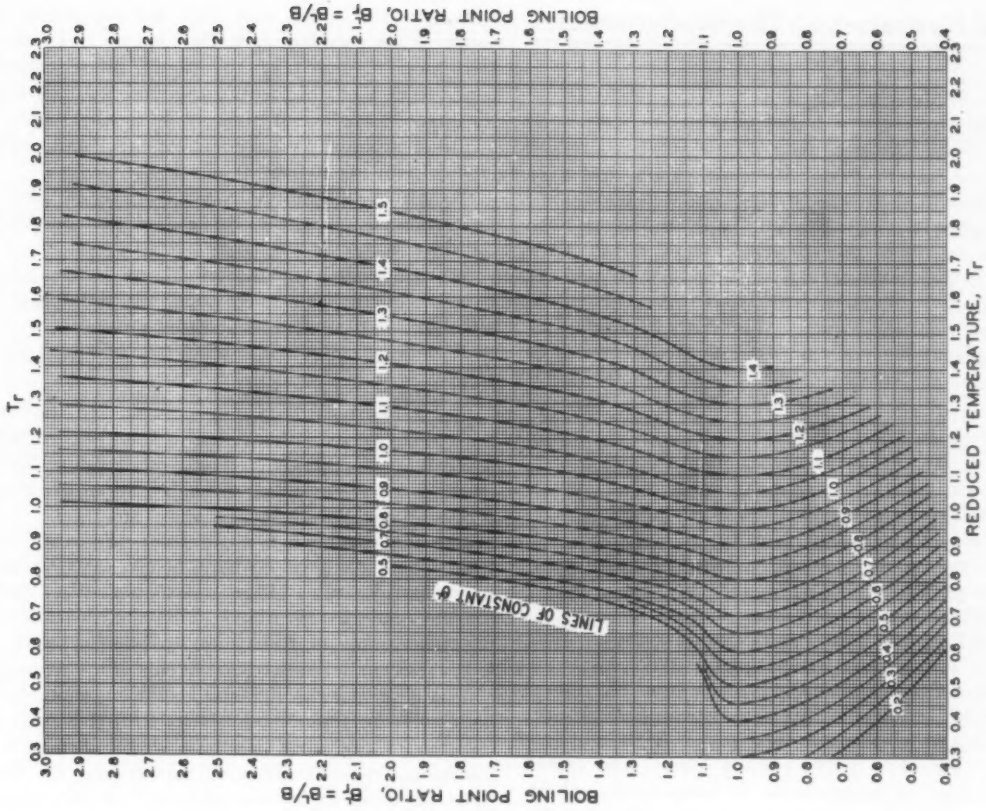


FIGURE 19.4—Generalized temperature—composition function hydrocarbon liquids.

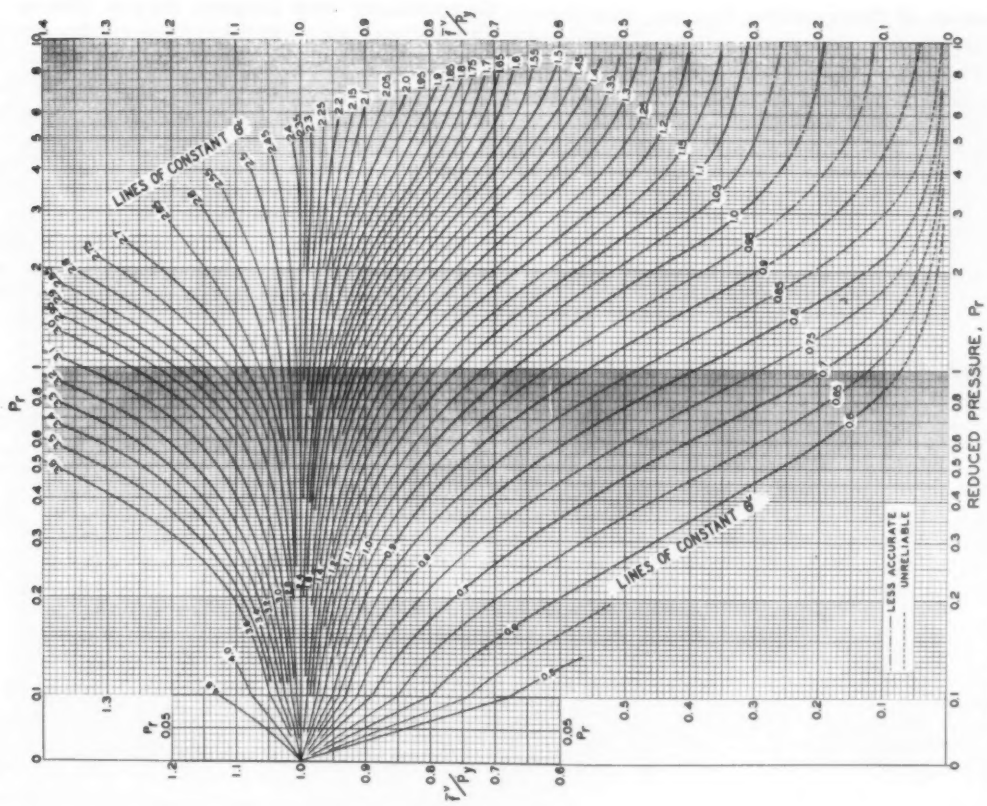


FIGURE 19.3—Generalized activity coefficients for vapor mixtures.

From this interpolation, a total of about 3000 values (an average of 250 for each hydrocarbon) were obtained from the 31,000 original data points for the plotting work. These smoothed and interpolated $\bar{f}/x$ and $\bar{f}/Py$ values covered a wide rang of $T_r$, $P_r$, and $B_r$ conditions. At the higher $B_r$ and $T_r$ conditions, the data were mostly for the lighter hydrocarbons; while the data for the heavier hydrocarbons fell in the lower $B_r$ and $T_r$ ranges. There was enough overlapping, however, to test the adequacy of any generalization.

Vapor pressures were required over a wide range of temperatures for converting the liquid fugacity coefficients ($\bar{f}/x$) to activity coefficients ($\bar{f}/P^{o}x$) for correlation development. Some of the temperatures of interest in this work fall below the boiling points of the heavier hydrocarbons, while others are above the critical points of the lighter components. Selected vapor pressure values are available below the atmospheric boiling point, but extrapolation is required to get values of $P_1{}^{o}$ above the critical temperature.

The method used to get values of $P^{o}$ was as follows: (a) use API Research Project 44[7] vapor pressure values up to the atmospheric boiling point, and (b) use a straight line on log P versus 1/T scales from the atmospheric boiling point through the critical point to get values above atmospheric boiling point. A straight line of log P versus 1/T scales gives a logical and reproducible method of extrapolation to temperatures above the critical. The values of $P^{o}$ obtained in this way and used in this correlation are given in Table 19.1.

**Development of Correlations.** Separate correlations were developed for each phase, giving the fugacity coefficients as functions of $P_r$, $T_r$, and $B_r$. This was done by plotting $\bar{f}/Py$ (and $\bar{f}/P^{o}x$) against $P_r$ for lines of constant $T_r$ for each $B_r$ value.

The regularity and progression with $B_r$ of these plots for each phase suggested the possibility of consolidation by means of an intermediate temperature-composition scale, $\Theta$, which is equal to $T_r$ at $B_r = 1.0$. In this way, the fugacity coefficients become functions of $P_r$ and $\Theta$, where $\Theta$ is a separate function of $T_r$ and $B_r$ for each phase.

Figures 19.1, 19.2, and 19.3 are the charts of the vapor phase correlation, while Figures 19.4, 19.5, and 19.6 are the charts of the liquid phase correlation. Separate $\Theta$-$T_r$-$B_r$ plots were required for methane, but the fugacity coefficient plots apply to all hydrocarbons.

The composite plots for each phase were developed in the following manner:

(1) Using a light table, the various $B_r$ plots were superimposed upon the $B_r = 1.0$ plot at matching coordinates,

(2) The values of $B_r$, $\Theta$ ($T_r$ at $B_r = 1.0$) and $T_r$ for each $B_r$ plot were tabulated and found to be essentially independent of reduced pressure.

(3) These values were plotted as Figures 19.1, 19.2, 19.4, and 19.5.

(4) Regions of data not covered by the original $B_r = 1.0$ plot were then filled in using values from the other $B_r$ plots and the $\Theta$-$T_r$-$B_r$ relationship. The final results were Figures 19.1 through 19.6 which cover the ranges of the Polyco data.

The two methane $\Theta$-$T_r$-$B_r$ plots (Figures 19.2 and 19.5) were extended to $B_r$ s below 1.0 by using the lines from the plots (Figures 19.1 and 19.4) prepared for the other hydrocarbons. This was done to extend the possible use of these plots to other systems.

Because $\Theta$ is a common parameter of the temperature-composition and the fugacity coefficient plots, it would be possible to replot both charts with $\Theta$ as one of the coordinates and then combine them to give a two-parameter representation, similar to the De Priester[5] plots. Examples of this two parameter plotting are shown in Figures 19.7 and 19.8.

**Comparisons with Original Polyco Values.** Table 19.2 presents the comparison between the generalized fugacity coefficient correlation and the original Polyco $\bar{f}/x$ and $\bar{f}/Py$ values. For the liquid phase, the absolute average deviation was found to be 4.1 percent for 624 points; and, for the vapor phase, the absolute average deviation was found to be 3.8 percent for 882 points. This is equal to an over-all average for both phases of 3.9 percent for 1,506 points.

The original Polyco fugacity charts contain uncertain and extrapolated or dashed-line regions. These regions have been indicated on the vapor phase chart (Figure

**TABLE 19.4—Deviation of Proposed Generalized Fugacity Coefficient Correlation from Experimental K-Values**

| | Binary Systems | | MULTICOMPONENT SYSTEMS | | | | All Systems | |
|---|---|---|---|---|---|---|---|---|
| | | | De Priester | | Other Data | | | |
| Hydrocarbon | Deviation, Abs. % | No. of Points | Deviation, Abs. % | No. of Points | Deviation, Abs. % | No. of Points | Deviation, Abs. % | No. of Points |
| Methane | 5.4 | 36 | 5.9 | 26 | 7.4 | 24 | 6.1 | 86 |
| Ethylene | 4.6 | 10 | .. | .. | 4.0 | 4 | 4.4 | 14 |
| Ethane | 3.2 | 29 | 9.8 | 29 | 5.8 | 12 | 6.4 | 70 |
| Propylene | 1.9 | 9 | .. | .. | .. | .. | 1.9 | 9 |
| Propane | 4.2 | 21 | 7.0 | 28 | 6.7 | 16 | 6.0 | 65 |
| *i*-Butylene | 4.5 | 6 | .. | .. | 7.2 | 4 | 5.6 | 10 |
| *i*-Butane | 1.6 | 6 | 9.8 | 6 | .. | .. | 5.7 | 12 |
| *n*-Butane | 5.1 | 12 | 7.1 | 19 | 10.5 | 6 | 7.0 | 37 |
| *n*-Pentane | 4.5 | 11 | 16.7 | 7 | 8.8 | 12 | 9.1 | 30 |
| *n*-Hexane | .. | .. | .. | .. | 12.1 | 1 | 12.1 | 1 |
| *n*-Heptane | 9.1 | 8 | .. | .. | .. | .. | 9.1 | 8 |
| 2, 2, 4-Trimethlypentane | .. | .. | 9.6 | 1 | .. | .. | 9.6 | 1 |
| *n*-Decane | .. | .. | 5.1 | 1 | 11.2 | 2 | 9.2 | 3 |
| Average All Hydrocarbon This Correlation | 4.4 | 148 | 8.2 | 117 | 7.4 | 81 | 6.4 | 346 |
| De Priester Charts | 6.3 | 88 | 6.3 | 116 | 6.7 | 54 | 6.4 | 258 |
| Kellogg Charts | 6.2 | 87 | 8.8 | 116 | 7.7 | 54 | 7.7 | 257 |

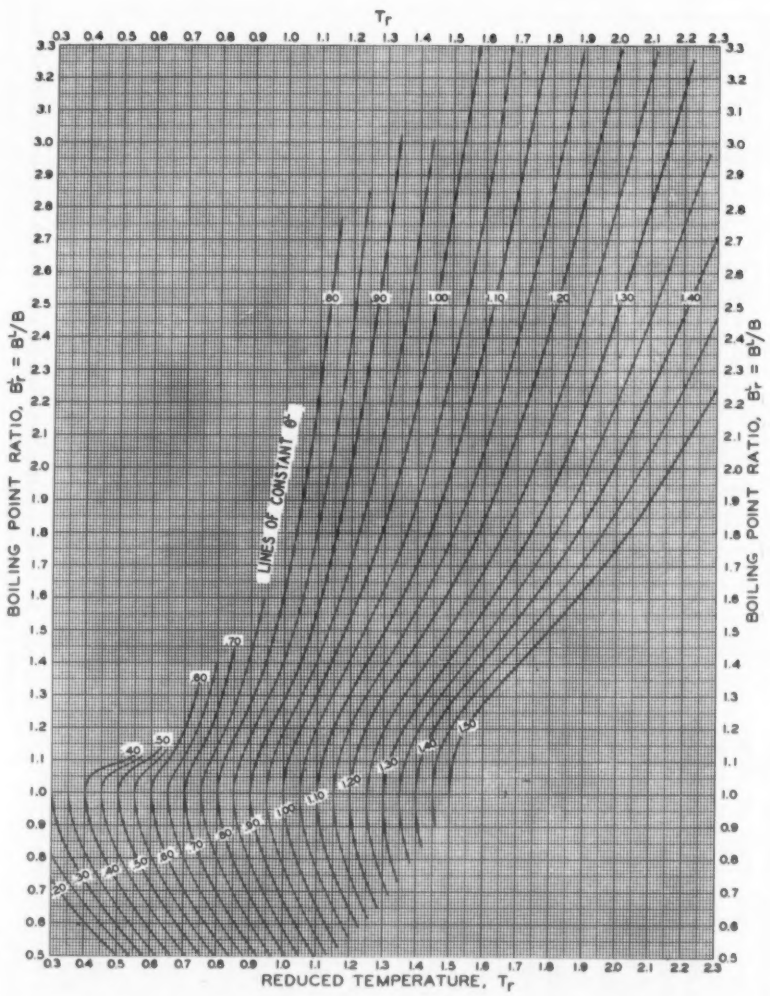


FIGURE 19.5—Generalized temperature—composition function methane liquid.

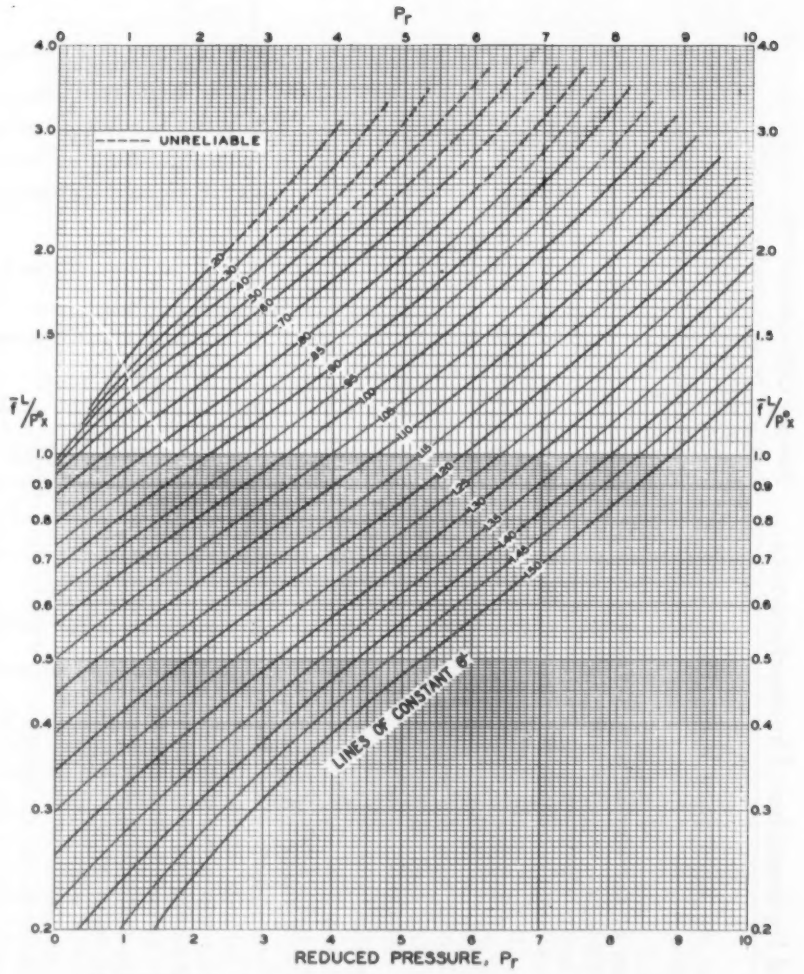


FIGURE 19.6—Generalized activity coefficients for liquid mixtures.

19.3) and the liquid phase chart (Figure 19.6) by dashed lines.

**Evaluation of Correlation with K-Values.** As indicated in Table 19.2, the agreement between the original Polyco fugacity charts and the proposed generalized fugacity coefficient correlation is quite good. However, a more practical test of the correlation is the prediction of vapor-liquid equilibrium distribution ratio. Accordingly, a comparison was made with experimental vapor-liquid K values from the literature. The sources and ranges of data used are shown in Table 19.3, while results of the evaluation are presented in Table 19.4.

The literature data used in this evaluation are divided into three categories: (1) binary, (2) De Priester multicomponent, and (3) other multicomponent systems. Comparisons were made in this way because binary data are the most reliable (due to greater experimental accuracy) and because of the large number of points in the De Priester multicomponent data. More points were used from this source than from any other single reference in order to put the proposed correlation to a severe test and to compare it with De Priester's recent recorrelation of the Kellogg charts.

Many recent binary and multicomponent data not included in De Priester's evaluation have been used in the current work. Some of these additional data are for higher pressures or lower temperatures than the range covered by De Priester's charts.

Referring to Table 19.4, it can be seen that the average absolute deviations of the proposed generalized activity coefficient correlation for all hydrocarbons are: 4.4 percent for 148 binary data points, 8.2 percent for the 117 De Priester multicomponent data points, and 7.4 percent for 81 other multicomponent data points. The average for all hydrocarbons in all systems is 6.4 percent for 346 data points.

Average deviations of De Priester and Kellogg charts for all hydrocarbons are included for comparison. The latter are from the evaluations made by De Priester and only apply to the atmospheric to 1,000 psi pressure range. All of the data points used by De Priester in his evaluations, plus the additional high pressure data, have been included in the evaluations of the proposed generalized correlation.

**Sample Calculations.** The application of this correlation will be illustrated by calculation of the K-values for a three-component mixture from the literature.[23] Following are the experimental data and the calculated molal average boiling points for each equilibrium phase at 160° F and 500 psia pressure.

| Hydrocarbon | OBSERVED DATA y | x | K = y/x | Atm. B.P., °R | M.A.B.P. CALCULATIONS yB | xB |
|---|---|---|---|---|---|---|
| Mentane | 0.661 | 0.116 | 5.90 | 201 | 132.9 | 23.3 |
| Propane | 0.238 | 0.259 | 0.919 | 416 | 99.0 | 109.7 |
| n-Pentane | 0.101 | 0.625 | 0.162 | 556.6 | 56.2 | 347.9 |
| | 1.000 | 1.000 | | | 288.1 | 478.9 |

The molal average boiling points are: $B^V$ = 288.1 °R and $B^L$ = 478.9 °R.
Reduced conditions are next found from
$B^V_r = B^V/B$
$B^L_r = B^L/B$
$T_r = (160 + 460)/T_c$
$P_r = 500/P_c$

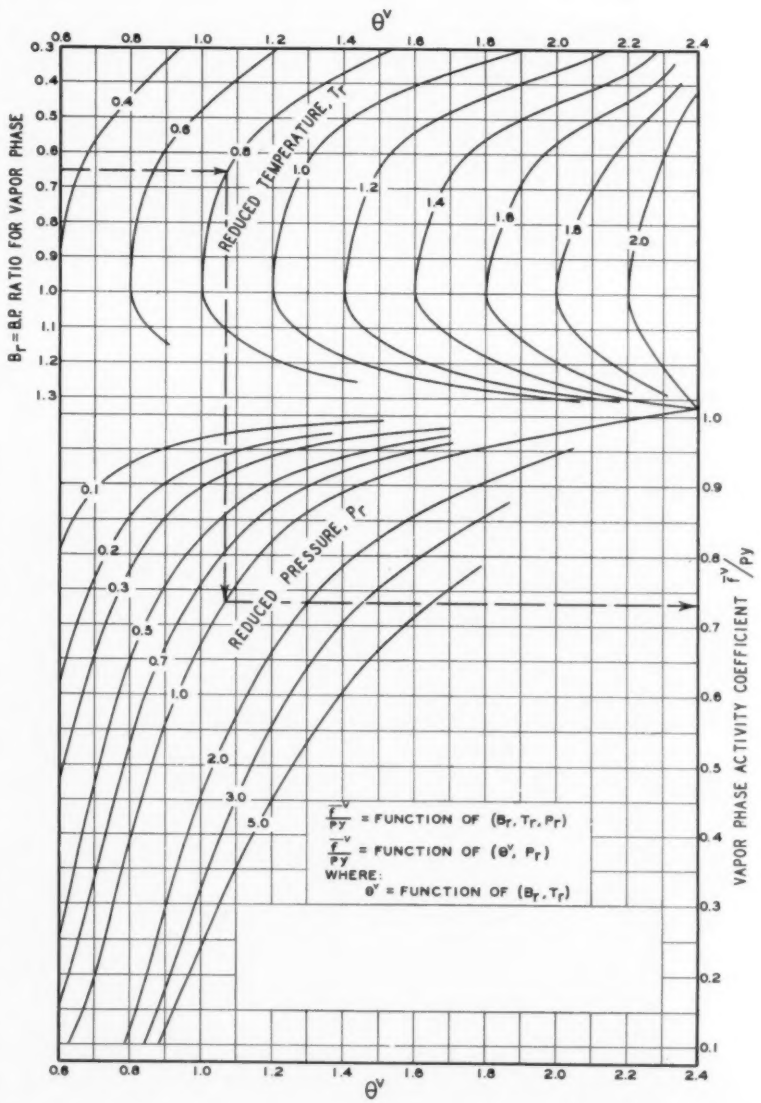
θ^V
B_r = B.P. RATIO FOR VAPOR PHASE
REDUCED TEMPERATURE, T_r
REDUCED PRESSURE, P_r
f^V/Py = FUNCTION OF (B_r, T_r, P_r)
f^V/Py = FUNCTION OF (θ^V, P_r)
WHERE:
θ^V = FUNCTION OF (B_r, T_r)
VAPOR PHASE ACTIVITY COEFFICIENT f^V/Py

**FIGURE 19.7—Two-parameter chart of generalized activity coefficients for components of vapor mixtures.**

| Hydrocarbon | B | Boiling Point Ratio | | Temperature | | Pressure | |
|---|---|---|---|---|---|---|---|
| | | $B^V_r$ | $B^L_r$ | $T_o$ | $T_r$ | $P_o$ | $P_r$ |
| Methane | 201.0 | 1.435 | 2.38 | 343.2 | 1.806 | 673.0 | 0.743 |
| Propane | 416.0 | 0.692 | 1.15 | 666.0 | 0.931 | 617.4 | 0.810 |
| n-Pentane | 556.6 | 0.518 | 0.86 | 845.6 | 0.733 | 490.0 | 1.020 |

With these reduced conditions, values of Θ and the fugacity coefficients are found from the charts.

| Hydrocarbon | VAPOR PHASE | | LIQUID PHASE | |
|---|---|---|---|---|
| | $\Theta^V$ | $\bar{f}^V/Py$ | $\Theta^L$ | $\bar{f}^L/P^o x$ |
| Methane | 2.47 | 1.009 | 1.215 | 0.385 |
| Propane | 0.99 | 0.715 | 0.900 | 0.79 |
| n-Pentane | 0.89 | 0.540 | 0.707 | 1.04 |

Values of $P^o$ at 160° F are found from Table 19.1, and K-values are computed by Equation 19.2. These values are compared with the observed values in the following:

| Hydrocarbon | $(\bar{f}^L/P^o x) / (\bar{f}^V/Py)$ | $P^o$ | $P^o/P$ | K-VALUES | |
|---|---|---|---|---|---|
| | | | | Calc. | Obs. |
| Mentane | 0.3815 | 7523 | 15.05 | 5.74 | 5.70 |
| Propane | 1.105 | 389.3 | 0.778 | 0.860 | 0.919 |
| n-Pentane | 1.925 | 31.9 | 0.0838 | 0.161 | 0.162 |

In this example, the compositions of the equilibrium phases were known so that the calculations were straightforward. Had these been unknown, successive approximations would have been necessary. These would start with assumed values of $B^V$ and $B^L$, which would be found after the K-values had been calculated and the equilibrium phases computed.

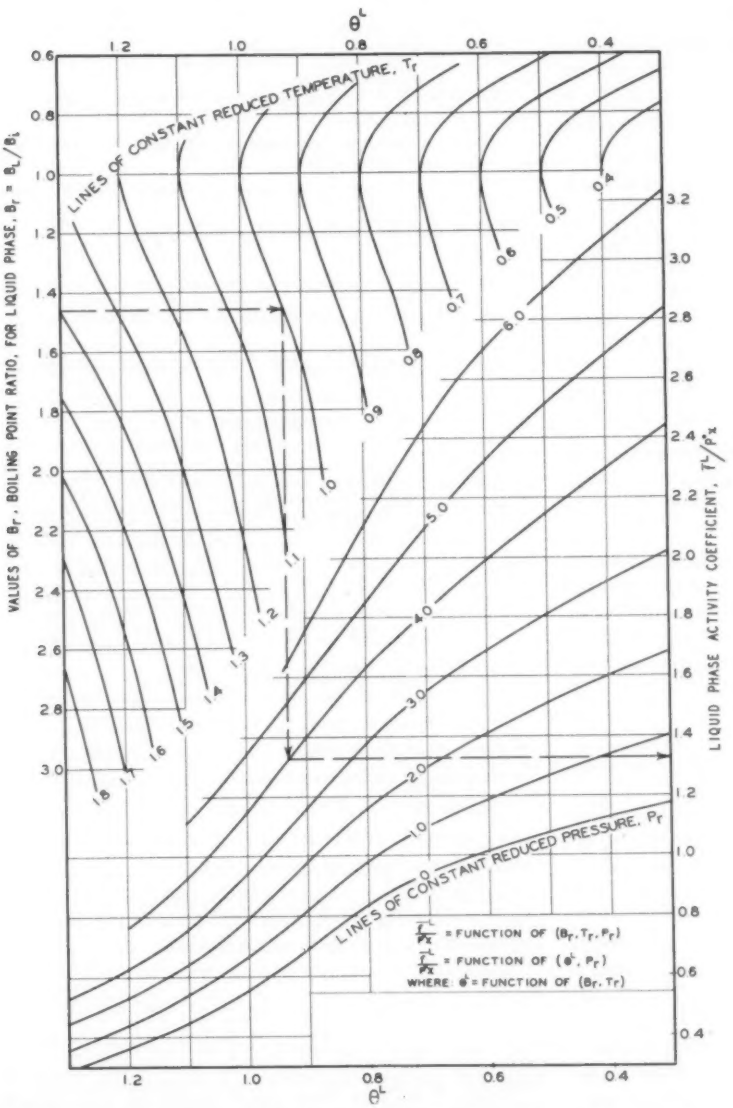
θ^L
LINES OF CONSTANT REDUCED TEMPERATURE, Tr
VALUES OF Br, BOILING POINT RATIO, FOR LIQUID PHASE, Br = BL/Bi
LIQUID PHASE ACTIVITY COEFFICIENT, f̄L/P°x
LINES OF CONSTANT REDUCED PRESSURE, Pr
f̄L/P°x = FUNCTION OF (Br, Tr, Pr)
f̄L/P°x = FUNCTION OF (θL, Pr)
WHERE θL = FUNCTION OF (Br, Tr)

**FIGURE 19.8—Two-parameter chart of generalized activity coefficients for components of liquid mixtures.**

**Partial Enthalpy and Volume.** Partial enthalpy and partial volume values can be derived from these generalized fugacity coefficient correlations by obtaining temperature and pressure derivatives.

The basic thermodynamic equations for these derivatives are

$$\overline{\Delta H} = \overline{H} - H^o = -RT^2\left(\frac{\partial \ln \bar{f}/x}{\partial T}\right)_{P,N} \tag{19.3}$$

$$\overline{V} = RT\left(\frac{\partial \ln \bar{f}/x}{\partial P}\right)_{T,N} \tag{19.4}$$

These equations, which are general and applicable to either liquid or vapor phase, are transformed to separate equations in generalized units for each phase.

For the vapor phase, the generalized partial enthalpy difference equation is:

$$\frac{\overline{\Delta H}^V}{RT_c} = -T_r^2\left(\frac{\partial \ln \bar{f}^V/Py}{\partial T_r}\right)_{P_r,B_r} = -T_r^2 \left[\left(\frac{\partial \ln \bar{f}^V/Py}{\partial \Theta}\right)_{P_r} \left(\frac{\partial \Theta}{\partial T_r}\right)_{B_r}\right] \tag{19.5}$$

The corresponding equation for the liquid phase must include a vapor pressure slope term.

$$\frac{\overline{\Delta H}^L}{RT_c} = -T_r^2\left(\frac{\partial \ln \bar{f}^L/x}{\partial T_r}\right)_{P_r,B_r} = -T_r^2 \left[\left(\frac{\partial \ln \bar{f}^L/P^o x}{\partial \Theta}\right)_{P_r} \left(\frac{\partial \Theta}{\partial T_r}\right)_{B_r}\right] + \frac{d \ln P^o}{d \frac{1}{T_r}} \tag{19.6}$$

Above the atmospheric boiling point, where $P^o$ values were obtained from a straight line on log $P^o$ vs $\frac{1}{T}$ plot, the last term in Equation 19.6 becomes

$$\frac{d \ln P^o}{d\frac{1}{T_r}} = \frac{\ln P_c/P_B}{1-\frac{T_c}{T_B}} \qquad (19.7)$$

A generalized equation for the partial volume differences of the vapor phase may be obtained from Equation 19.4 by combining with the ideal gas volume ($V^o = RT/P$) and changing to reduced units, as follows:

$$\overline{\Delta V} = \overline{V} - RT/P = RT\left[\left(\frac{\partial \ln \overline{f}/x}{\partial P}\right)_{T,N} - \frac{1}{P}\right] \qquad (19.8)$$

The right hand member of Equation 19.8 can be simplified by replacing the $P^{-1}$ term by its equivalent d ln P/dP and combining terms. This plus the introduction of reduced units leads to

$$\overline{\Delta V}\left(\frac{P_c}{RT_c}\right) = T_r\left(\frac{\partial \ln \overline{f}^V/Py}{\partial P_r}\right)_{T_r,B_r} \qquad (19.9)$$

where $\overline{\Delta V} = \overline{V} - V^o$ = partial volume difference in the same units as $RT_c/P_c$.

Because of the vapor pressure term $P^o$, the generalized equation for the partial enthalpy difference of the liquid contains an extra term. Noting that the pressure derivative of vapor pressure is zero, Equation 19.4 is transformed to generalized dimension for the liquid phase:

$$\overline{\Delta V}\left(\frac{P_c}{RT_c}\right) = T_r\left(\frac{\partial \ln \overline{f}^L/P^o x}{\partial P_r}\right)_{T_r,B_r} - \frac{T_r}{P_r} \qquad (19.10)$$

The pressure derivatives of the fugacity coefficients in Equations 19.9 and 19.10 are at constant $T_r$ and $B_r$ or at constant $\Theta$.

**Conclusions.** Generalized correlations, giving vapor and liquid fugacity coefficients as functions of reduced temperature, reduced pressure, and boiling point ratio, have been developed from the fugacity values recently obtained by Benedict et al[2] for 12 light hydrocarbons at pressures up to 3,600 psi and are presented on 276 charts.

In reducing the data from 276 charts to six charts, a correlation was developed that can be used to estimate values for other hydrocarbons and conditions.

This correlation can be used directly in reduced units to obtain equilibrium vapor-liquid distribution ratios, or it can be used to prepare K-value plots for individual hydrocarbons with specific (°F or °C) and pounds per square inch or atm) scales.

This correlation is applicable to paraffin and olefin hydrocarbon systems, as the data used in developing the correlation were for these hydrocarbons. The use of boiling points as the composition parameter may be considered as taking into account the effects of molecule size. For mixtures containing other hydrocarbons, such as aromatics of naphthenes, an additional composition correction for differences in molecule character must be applied.

Another application of these generalized fugacity correlations might be the derivation of partial thermodynamic properties, such as partial enthalpy and volume, as shown by Equations 19.3 through 19.10. Calculating these partial properties requires the temperature and pressure derivatives of these fugacities. Obtaining precise values of these derivatives from these generalized correlations is too much to expect, as will be shown in a later installment.

## NOMENCLATURE

- $R$ = universal gas constant, Btu/lb mole °R
- $T$ = temperature, °R
- $T_r = T/T_c$ = reduced temperature, where $T_c$ is critical temperature, for any component.
- $P$ = pressure, psia
- $P^o$ = vapor pressure, psia
- $P_r = P/P_c$ = reduced pressure, where $P_c$ is critical pressure, for any component.
- $B$ = normal atmospheric boiling point, °R, for any component
- $B^V$ = molal average boiling point ($\Sigma yB$) of components in vapor phase, °R
- $B_r{}^V = B^V/B$ = boiling point ratio for any component in the vapor phase
- $B_r{}^L = B^L/B$ = boiling point ratio for any component in the liquid phase
- $\Theta^V$ = temperature-composition parameter for any component in vapor phase
- $\Theta^L$ = temperature-composition parameter for any component in liquid phase
- $\overline{f}^L/x$ = fugacity coefficient of any component
- $\overline{f}^L/P^o x$ = fugacity coefficient of any component in liquid phase
- $\overline{f}^V/Py$ = fugacity coefficient of any component in vapor phase
- $\overline{\Delta H} = \overline{H} - H^o$ = partial enthalpy difference for any component
- $\overline{\Delta V} = \overline{V} - RT/P$ = partial volume difference for any component

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# How to Check the Russian Literature

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YOU CAN NO LONGER ignore the Russian technical literature. The Soviet Union now ranks second among all nations in output of chemical literature. Russia produces one seventh of the world's chemical and chemical engineering literature, half as much as America. Still most of this literature goes unnoticed by American engineers.

The Russians publish their chemical engineering articles in a large number of magazines. Ivan, the Soviet chemical engineer, does not have any single journal which is devoted to his profession. This is because Ivan is a specialist to a much higher degree than his American counterpart, and so Ivan has little interest in what other chemical engineers are doing.

Consequently the American engineer who wishes to follow the progress of Soviet chemical engineering must monitor a rather large number of periodicals. The table below describes the major Russian periodicals which contain chemical engineering information, but this is by no means the complete list. Some of the journals listed are now available in full English translation, as indicated by an asterisk. These translated journals appear late—usually about a year after Russian publication. For information about obtaining Russian periodicals, Reference 33 should be consulted. For information about translated periodicals, Reference 34 is recommended. Both are available free upon request.

1. *Chemical Industry (Khimicheskaya Promyshlennost)*, published eight times yearly by the Ministry of Chemical Industry. It contains many articles of interest to chemical engineers, chiefly review articles concerning chemical manufacturing industries and industrial processes. This is the major Soviet periodical of interest to chemical engineers.

2. *Journal of Applied Chemistry* (Zhurnal Prikladnoi Khimii)*, monthly publication of the USSR Academy of Sciences. The emphasis is on chemical processes, but there are frequent articles on chemical engineering subjects, especially distillation and extraction. Electrochemistry, geochemistry, and metallurgical chemistry are prominently featured.

3. *Proceedings of the U.S.S.R. Academy of Sciences* (Doklady Akademii Nauk S.S.S.R.)*, published three times monthly by the Academy. It contains several sections of interest to chemical engineers: chemistry, physical chemistry, chemical technology, hydrodynamics, and technical physics. Articles are brief, intended primarily to report current research. The progress of Soviet research in many fields is reported here.

4. *Chemistry and Technology of Fuel and Oil (Khimiya i Tekhnologiya Topliv i Masel)*, published monthly by the State Scientific and Technical Committee of the Council of Ministers of the USSR. Its title describes its contents well. There are occasional articles on refining processes.

5. *Gas Industry (Gazovaya Promyslennost)*, monthly joint publication of the Council of Ministers of the USSR, the Ministry of Communal Economy of the RSFSR, and the Scientific and Technological Society of the Electric Power Industry. It feasures occasional articles on gas technology.

6. *Transactions of the All-Union Institute of Scientific Research on Petroleum and Gas Refining and Production of Artificial Liquid Fuel (Trudy Vsesoyuznyi Nauchno-issledovatel'skii Institut po Pererobotke Nefti i Gaza i Polucheniyu Iskusstvennogo Zhidkogo Topliva)*, published irregularly by the Institute. Refining is prominently featured.

7. *Azerbaijan Scientific Research Institute of the Petroleum Refining Industry. Collected Papers Azerbaidzhanskii Nauchno-Issledovatel'skii Institut Neftepererabatyvaiuschei Promyshlennosti. Sbornik Trudov)*, published irregularly by the Institute. This is the major petroleum-technology journal emanating from the major oil-producing province of Russia.

8. *Journal of General Chemistry* (Zhurnal Obshchei Khimii)*, published monthly by the U.S.S.R. Academy of Sciences. There are no articles on chemical engineering, but many on reactions and materials of interest to applied chemists.

9. *Journal of Physical Chemistry* (Zhurnal Fizicheskoi Khimii)*, published monthly by the USSR Academy of Sciences. This journal's contents resemble those of the American journal of the same title.

10. *Progress of Chemistry (Uspekhi Khimii)*, published monthly by the USSR Academy of Sciences. Review articles are featured, many of them dealing with chemical technology.

11. *Bulletin of the U.S.S.R. Academy of Sciences, Division of Technical Science (Izvestiya Akademii Nauk SSSR, Otdelenie Teknicheskikh Nauk)*, published monthly by the Academy. The sections on chemical technology, heat technology, hydrodynamics, metallurgy, and "brief communications" are all of occasional interest.

12. *Bulletin of the U.S.S.R. Academy of Sciences, Division of Chemical Science* (Izvestiya Akademii Nauk SSSR, Otdelenie Khimicheskikh Nauk)* published monthly by the Academy. Subjects are strictly chemical, seldom of direct interest to chemical engineers.

13. *Chemical Science and Industry (Kimicheskaya Nauka i Promyshlennost)*, monthly publication of the Mendelyeev Society. It is given largely to general articles on inorganic technology. Chemical engineering topics appear often.

14. *Colloid Journal* (Kolloidnyi Zhurnal)*, published bimonthly by the USSR Academy of Sciences. It occa-

sionally contains articles of interest to chemical engineers. Main subject is colloid chemistry.

15. *Industrial Laboratory* (Zavodskaya Laboratoriya)*, published monthly by the Ministry of the Metallurgical Industry. Laboratory methods, mainly metallurgical, are featured.

16. *Journal of Technical Physics* (Zhurnal Teknicheskoi Fiziki)*, published monthly by the USSR Academy of Sciences. It contains occasional articles on transport phenomena, from an advanced standpoint.

17. *Petroleum Economy (Neftianoe Khoziaistvo)*, published monthly by the Ministry of Petroleum Industry. This is mainly an industry reporter, but occasional articles on refining are of interest to chemical engineers.

18. *Heat Energetics (Teploenergetika)*, published jointly each month by the Ministry of Electric Power Stations and the Ministry of Machine Construction. Heat transfer processes are featured.

19. *Oxygen (Kislorod)*, published bimonthly by the State Scientific and Technical Committee of the Council of Ministers of the U.S.S.R. There are occasional articles on heat transfer and low temperature processes. Emphasis is placed on oxygen plants.

20. *Bulletin of the Institutes of Higher Learning, Chemistry and Chemical Technology Series (Izvestiya Vysshikh Uchebnikh Zavedenii, Seria Khimiya i Khimicheskaya Tekhnologiya)*, published bimonthly by the Ministry of Higher Education of the USSR. Publication began in 1958. The articles on chemical technology seem to be valuable for chemical engineers. Chemistry predominates.

21. *Coke and Chemistry (Koks i Khimiya)*, published monthly by the Ministry of Ferrous Metallurgy. It relates mainly to operation of gas works.

22. *Atomic Energy* (Atomnaya Energia)*, published monthly by the USSR Academy of Sciences. Chemical engineering articles are infrequent.

23. *All-Union Scientific Research and Design Institute of Chemical Machinery. Collected Papers (Vsesoyuznii Nauchno-Issledovatel'skii i Konstruktorskii Institut Khimicheskigo Mashinostroeniya. Sbornik Statei)*, published irregularly by the Institute. Typical titles include "Physical Processes and the Principles of Analyzing Thermochemical Equipment," "Materials Used in the Chemical Machinery Industry."

24. *Metallurgist* (Metallurg)*, published monthly by the Ministry of Ferrous Metallurgy. Ferrous metallurgy is featured.

25. *Metals and Heat Treatment of Metals (Metallovedenie i Termicheskaya Obrabotka Metallov)*, published jointly each month by the State Scientific and Technical Committee of the Council of Ministers of the USSR, the Central Scientific Research Institute of Technology and Machine Building, and the Scientific Technological Society of the Machinery Industry. It includes practical studies of metals and alloys, with emphasis on heat treatment.

26. *Steel* (Stal')*, published monthly by the State Scientific and Technical Committee of the Council of Ministers of the USSR. Its principal concern is steel production.

27. *Nonferrous Metals (Tsvetniye Metally)*, published monthly by the Ministry of Metallurgical Industry.

28. *Journal of Engineering Physics (Inzhenerno-Fizicheskii Zhurnal)*, published monthly by the Academy of Sciences of the Belorussian SSR. There are frequent articles of interest to chemical engineers; physical processes, such as mass and heat transport and particle dynamics, are featured.

29. *Research Papers of the Higher Schools; Chemistry and Chemical Technology (Nauchnye Doklady Vysskei Shkoly; Khimiya i Khimicheskaya Tekhnologiya)*, published quarterly by the Ministry of Higher Education of USSR. Emphasis is on inorganic chemistry, with occasional chemical engineering articles. There are also the following series: *Petroleum and Gas, Ferrous Metallurgy, Nonferrous Metallurgy.*

30. *Journal of Inorganic Chemistry* (Zhurnal Neorganicheskoi Khimii)*, published monthly by the USSR Academy of Sciences.

31. *Abstract Journal, Chemistry (Referativnii Zhurnal, Khimiya)*, published twice monthly by the Institute of Scientific Information, USSR Academy of Sciences. This gives comprehensive coverage of Russian chemical literature, in a format much like that of *Chemical Abstracts.*

32. *Abstract Journal, Metallurgy* (Referativnii Zhurnal, Metallurgiya)*, published monthly by the Institute of Scientific Information, USSR Academy of Sciences.

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## About the Author

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# Corrosion Measurement Short Course

## Part 1: Inspecting Corrosion Damage
## Part 2: Onstream Corrosion Measurement
## Part 3: Finding the Cause of Corrosion Damage

**A. J. Freedman, A. Dravnieks and B. Ostrofsky**
Standard Oil Company (Indiana), Whiting, Ind.

PARTS 1 AND 2 showed you how to measure corrosion and determine the damage done to process equipment.

This final part of the series delves into the causes of corrosion damage. Thus, the corrosion engineer has at his command the means to measure the corrosion taking place in his process stream, the tools and techniques to inspect for corrosion damage, and the methods available for investigating the causes of corrosion damage.

### INVESTIGATING UNUSUAL CORROSION FAILURES

**Diagnostic Methods.** Corrosion damage may be discovered either during a shutdown inspection, or unexpectedly, while onstream.

Sometimes, the damage may have been "natural," that is, well anticipated and the agressive agent well-known. No further steps except repair or replacement may be necessary.

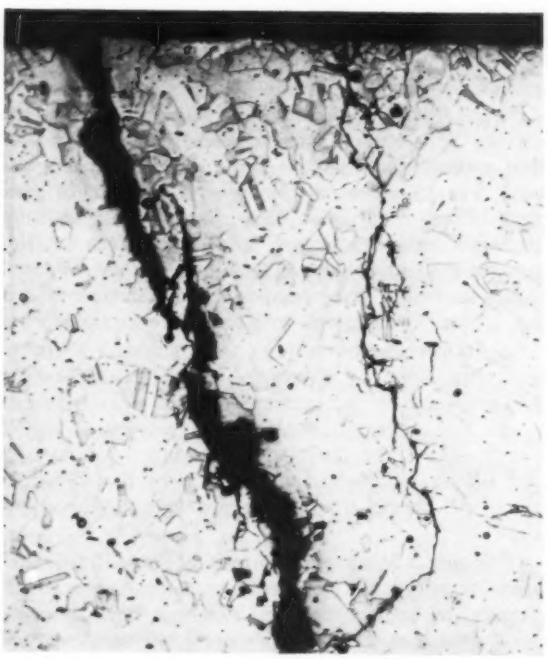

**FIGURE 18—Metallographic examination shows this transgranular cracking of an 18-8 stainless steel thermocouple well.**

At other times, the exact cause may not be obvious. A careful diagnosis then must follow. This diagnosis requires the massive application of all available scientific means, in addition to gathering background information on past operation of the refinery unit where the failure occurred. A typical "mark sheet" which might be used in compiling the background data is shown in Table 1.

Depending on the size of the organization, the available scientific means differ. In a large organization, all of the required skills usually are available. In smaller companies, samples can be sent to commercial laboratories, where the required equipment and personnel are available.

**Typical Procedure for Investigating Corrosion Failure.** (a) The failed part is brought over to the laboratory, without having been cleaned or tampered with. The damage is *photographed* immediately, to document its appearance. (b) Corrosion deposit samples are taken. There samples are subjected to *X-ray diffraction* analysis, sometimes to *electron diffraction* analysis, and examined under the *petrographic microscope,* to establish the types of compounds formed by corrosion or deposited from the stream. *Spectrographic, X-ray fluorescence,* and chemical *analytical* and *micro-analytical* tests are performed on the deposits, to establish their chemical composition. (c) Sections of the damaged part are cut and prepared for *metallographic* examination. In this examination, the metallurgist observes the nature of the attack. The corrosion may be uniform, or pitting may occur. Pit size, form, relation to the grain structure and deposits in the pit, all may furnish useful clues to the cause of attack. Presence of intergranular attack, carburization, decarburization, paths of cracks, etc., are other characteristics of the utmost importance in establishing the nature of the damage. *Composition analysis* and structure of the metal aid in deciding whether or not the proper metal in the proper heat treatment state was used. *Mechanical* tests may be necessary if hardening or embrittlement is suspected.

If available, the process fluid which caused the damage is sampled and analyzed chemically for possible corrosive components.

**Examples.** Not all of the techniques mentioned above are equally useful in every case, but if the materials failure was critical, one should leave no stone unturned to find the cause and a solution. A few cases may illustrate the usefulness of various techniques.

In one case, an 18-8 stainless steel thermocouple well which had been installed through the wall of a vessel,

cracked at the location where the outside insulation ends. Metallographic examination (Figure 18) revealed transgranular cracking as well as the presence of an abnormally high amount of inclusions. Sulfur printing, a technique in which a polished cross-section of the specimen is pressed for a brief time against sulfuric acid-moistened photosensitive paper to produce a silver sulfide contact print from FeS and other sulfides, showed no evidence of sulfidic attack. Microanalysis of the deposits from the outside of the tube for chlorides by a microdiffusion method indicated the presence of 0.1 percent chloride. Although in normal operation the tube is hot, the findings indicated that the failure occurred by chloridic stress corrosion cracking, most probably during the warmup of the equipment, and that the poor quality of the alloy contributed to failure. Further search indicated that the chlorides probably originated from a leak from the vessel. The inner ends of the thermocouple wells were sealed by plug-welds which apparently leaked. Another possible source might have been chlorides in the insulation surrounding the vessel.

**TABLE 1—Mark Sheet for Corrosion Failures**

When forwarding damaged parts for inspection, please leave the parts dirty (as they come from the unit)! Do not destroy valuable clues in the corrosion and sludge deposits! Try to protect parts from additional rusting by keeping them in a dry location. Take samples in clean dry glass bottles. Identify samples as fully as possible.

Date:
Person most familiar with the case:

Refinery:
Unit:
Equipment (heat esch., compressor, etc.):
Damaged Parts (tube, spring, etc.):
Operating Conditions:
A. On Corroding Side
Temperature (or temp. range): Pressure:
Fluid: (oil, water, gas, etc.) (vapor or liquid):
B. On the Other Side
Temperature: Pressure:
Fluid:
Description of Processed Stream:
A. Where it comes from:
B. Where it goes:
C. Possible components, inhibitors:
D. Analysis if known:
When was the difficulty discovered:
A. Last known inspection date: findings:
B. When was damaged part first put in service?
C. Brief schedule of last several operations:
On stream: Down:
On stream: Down:
On stream: Down:
D. Shutdown procedure (steam, etc.):
Brief description of the extent and type of failure:
(Use attached sheet for a free hand pencil sketch of the particular unit, indicating the points of damage.)
Conditions of other parts of the unit (corrosion, fouling, etc.):
Materials of construction (damaged part as well as surrounding surfaces):
Any previous experience with a similar difficulty:
Other information which may be related, even remotely (process difficulties, unusual feed, instrument failures, etc.):
Any analyses of the deposits available? If yes, attach or quote:
Possible explanations which have been advanced:
What are immediate plans to deal with the damage?
(Separate Page)
Free Hand Pencil Sketch of the Unit (e.g. Heat Exchanger), Indicating Points of Damage

In another case, (Figure 19) a naphtha heater furnace tube was found holed through after a shutdown. No defects or peculiarities indicating hydrogen blistering were found on metallographic examination. The corrosion products were scales of FeS, FeO and $Fe_3O_4$. The scales had a pH of 6 and contained polythionic acids and chlorides, indicating that acid cleaning of the iron sulfide coated tubes had been unsatisfactory. Subsequent alkalizing and washing was not sufficient to arrest oxygen concentration cells. This caused galvanic interaction between the scale and the steel. Holes and pits in this case occurred only on the bottom side of the tube on the inner surface, and were concentrated in the middle portion of the tube which had formed a trough by normal sagging.

Practice has shown that misidentification of alloys or failure to obtain proper specified composition and heat treatment is one of the most common causes of "freak" difficulties. A few examples may be mentioned: cracking of monel fan blades accidentally welded with stainless steel: dezincification of Admiralty metal tubing on the water side because of low inhibitor content in the alloy; intergranular attack and cracking in weld-affected sensitized zones in Type 304 stainless steel furnace tubes during shutdown, caused by polythionic acids formed from the action of steam on sulfide scale during steaming operations; etc. A positive identification of the composition and structure of the alloy is imperative in each corrosion or cracking damage investigation. All too often much time is lost on reasoning based only on hearsay evidence on these items.

**Simulation of Corrosion Failures.** The previous section discussed methods for a post mortem investigation of corroded equipment that has been brought to the laboratory. The result of such investigation, analytic in a broad sense, is a mental reconstruction of the mechanism of damage. The next step is to find possible means for preventing recurrences, or at least making the problem less serious in the future.

Here previous experience, literature references, and contacts with other corrosion people through the technical societies provide the first line of approach, and may indicate a feasible solution. A number of good compilations of corrosion data are available,[23-26] listing the behavior of metals and alloys in various environments. Frequently, however, all these simpler means of finding a remedy are inadequate. At this stage, laboratory and field corrosion tests enter the picture.

Laboratory corrosion tests, as compared with the field tests, have the advantage of great flexibility and time economy. In the laboratory, factors can be varied at will and a great amount of exploratory work can be done rapidly. The purpose of laboratory testing is to find alloys, inhibitors, and chemical or design factors which will permit trouble free operation of the equipment.

**Designing Laboratory Corrosion Tests.** Laboratory corrosion tests require much more than merely standard chemical laboratory facilities. The tests must be realistically pertinent. If the equipment has welded sections, welds prepared on large test pieces have to be studied in order to approach, during welding, such thermal conditions and cooling rates as exist in the plant. If the

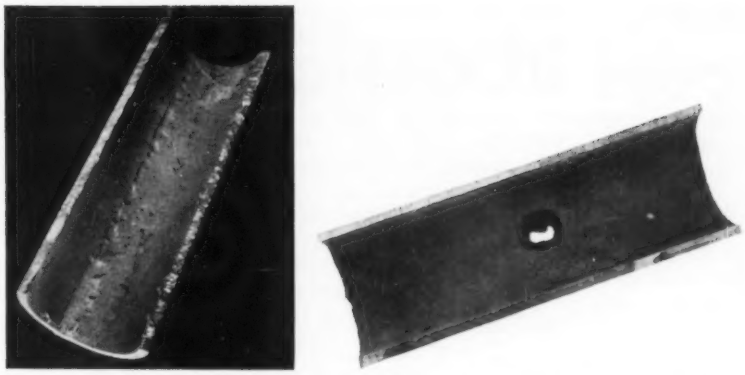

**FIGURE 19—Holes and pits in these sections of a naphtha furnace tube were caused by galvanic attack between the scale and the steel.**

plant stream operates at negligible dissolved oxygen levels, it would be wrong to test inhibitors in stream samples taken, stored, and tested in open glassware. If the corrosion problem is in bends or nozzles, laboratory tests must reproduce high velocities and turbulence. If the problem concerns heat exchanger tubes, the temperature of the test specimens should correspond to the skin temperature of the tubes, rather than to the stream temperature. If corrosion is caused by minute amounts of a corrosive aqueous phase trapped in an oily phase, care must be taken to have this factor represented in the tested stream samples. If corrosion occurred in crevices, or under deposits, as is frequently observed in acid cleaning, similar conditions have to be designed into the laboratory tests. This list of "ifs" can be continued at length. The most common "if" is that if the corrosion occurs in equipment under pressure, laboratory tests in conventional glassware, because of lower pressure, fail to come close to the temperature of the plant stream and do not reproduce the severe plant conditions.

Failure to recognize some specific chemical or physical factors significant in a given case, and failure to reproduce these factors in laboratory tests are the principal reasons why many practical plant people have come to pay only token attention to laboratory corrosive test results.

However, it does not have to be so. Present day laboratory pilot plant techniques give qualified corrosion men the capacity to reproduce practically any factor and combination of factors which may affect plant performance.

**Corrosion Laboratory Equipment.** It is very important for a corrosion testing laboratory to build up an inventory of certain basic pieces of equipment. With this equipment, various more complex schemes can be set up to reproduce corrosive conditions. In this short article, only brief mention of some types of useful equipment can be made.

All types of devices are necessary for producing *temperature conditions*. These include: portable refrigerated baths; water thermostats for temperatures from atmospheric to 200° F; aluminum blocks or aluminum powder baths, useful up to 950°-1,000° F with tubing type totally encapsuled heaters; and tube furnaces for higher temperatures. Thermal gradient furnaces are great time savers in tests where a temperature range has to be scanned. In such furnaces, for instance, there may be a zone of 12 inches with a constant temperature drop of 50°-60° F per inch.

Temperatures are regulated with proportioning type thermocouple controllers, or, for lower temperatures, with mercury contact thermometers. For dependability in long duration tests, parallel actuated relays connected in series save many tests which might otherwise be ruined by the failure of one temperature control relay. Many corrosion testing set-ups may require several temperature controllers, if prolonged steady operation in all parts of the set up is necessary. More controllers permit more simultaneous tests. It is difficult to overstock a corrosion laboratory with temperature controllers.

For producing circulating conditions, bellows pumps, flexible liner pumps, and peristaltic action pumps are useful. For higher pressures, high alloy chemical piston pumps are routine where cylinder gas pressure is inadequate or can not be conveniently applied. For velocity tests, the laboratory should have a supply of synchronous electric motors.

For producing proper chemical environments, either representative plant streams or synthetic streams can be used. The most frequent problem is that of introducing a minor component at low concentration into either type of stream sample, in order to explore the influence of these minor components on the corrosivity. In a

**FIGURE 20—A well designed and equipped laboratory improves the results of corrosion measurements.**

continuous flow system, this requires the use of motor-driven syringes, or bubblers with proper liquids at proper constant temperatures. Gas bubbling through such a liquid picks up vapor at a partial pressure determined by the temperature of the liquid. Gas flow rates are stabilized by manostats.

Corrosion measurements are made either with coupons or with corrosion probes. In the laboratory, corrosion tests may easily be conducted at constant temperatures. This simplifies the use of corrosion probes, since the temperature-compensating reference sample frequently is not necessary. A view of a laboratory equipped with exhaust hoods, temperature control panels overhead, and a centralized corrosion probe recorder and control circuit in the rear of the room, is shown in Figure 20.

In addition, devices for corrosion fatigue, stress corrosion, impingement corrosion, etc. are necessary to complete the collection of hardware for corrosion testing.

From the various elements described, it is possible to design laboratory corrosion tests to meet almost any requirement. For instance, aside from the merits of corrosion inhibitors under simple immersion conditions, tests under velocity, crevice, or impingement conditions may be significant in certain cases. These can all be devised in a properly equipped corrosion laboratory.

The principal advantage of laboratory tests is that it is possible to vary each factor over a wide range, and assess the relative significance of each factor in determining the corrosion rate. This provides a sound basis for estimating what effects controllable or uncontrollable changes in concentrations, temperatures, presence of certain constituents, or in other variables may have on corrosion rates in the plant equipment. Laboratory tests also permit a rapid screening of many inhibitors, alloys and alloy heat treatments, to select the most promising materials for further field tests.

The important thing to remember is that each corrosion test has to be tailormade, and its interpretation with relation to expected field results has to be conservative, much more in terms of trends caused by certain factors, than in terms of actual corrosion rates to be expected in the refinery. Intelligently obtained and interpreted, these results are of immense help in solving complex problems.

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Freedman

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# Use Computers to Select Exchangers

**The discussion here will help you decide whether a digital computer is worth its cost. A sample program is proposed to show the steps to take in rating a typical exchanger**

**Dale L. Gulley**
Western Supply Company, Tulsa

DOES YOUR COMPANY still rate (size) heat exchangers by hand? Most hand rating is unnecessary if you have at least a medium size digital computer.

In this article are aids in deciding whether a computer has economic justification. After reading this you should be able to decide the minimum computer size for your purpose. If you have a computer, you will find a sample program set-up here and heat transfer information reduced to a form the computer can use.

| | SHELL | TUBE |
|---|---|---|
| Inlet Temperature, °F. | | |
| Outlet Temperature, °F. | | |
| Flow Liquid (excluding water), lb./hr. | | |
| Water, lb./hr. | | |
| Gas, lb./hr. | | |
| Condensing steam, lb./hr. | | |
| Specific Heat, Btu/lb. | | |
| Viscosity (avg.), cp. | | |
| Viscosity (wall), cp. | | |
| Oil Specific Gravity @ 60° F. | | |
| Liquid Density (avg.), lb./cu. ft. | | |
| Gas Molecular Weight | | |
| Compressibility Factor | | |
| Operating Pressure, psia | | |
| Allowable Pressure Drop, psi | | |
| Film Coefficient (if known) | | |
| Heat Load, Btu/hr. | | |
| Max. Over-all Transfer Coefficient | | |
| Tube O.D., in. | | |
| Tube BWG | | |
| Tube Length, ft. | | |
| Tube Pitch (1) 15/16, (2) 1, (3) 1-1/4, or (4) 1-1/4 | | |
| Overall fouling | | |
| Shell Design Pressure, psi | | |
| Corrosion Allowance, in. | | |

**FIGURE 1—For computers having a capacity of less than two thousand words, this input form will be changed slightly.**

Here is what you can do on a digital computer. First you supply it with the necessary process and mechanical specifications. The computer can then supply:

- Number of exchangers and arrangement
- Surface
- Shell diameter and length
- Number of tube passes
- Pressure drop of both streams
- Over all heat transfer coefficient
- Baffle pitch and cut

It is also possible to calculate body flange dimensions, over-all dimensions, weight and manufacturing costs.

## WHAT SIZE COMPUTER?

Dimensional size or price of a computer is not necessarily a true indication of its capacity. With the nature of our problem in mind, the best means of computer classification is by the amount of memory it has.

Computer memory is measured in quantities called words. A word can be either a number or a command for the computer to perform. In the case of number storage the number of digits per word varies between computers. Usually there are 7-10 digits per word.

**In selecting a computer,** be careful when comparing memory capacity. Some computers do not have all of their memory available for computation. This unavailable memory is used for functions common to any program. Other computers get around this by using circuitry instead of memory to accomplish the same thing.

As previously mentioned a memory word usually consists of 7-10 digits. Since usage of more than three significant figures in heat transfer computations is questionable, part of the word is not being utilized. It is possible in some computers to make a more effective use of the memory. This is done by ingeniously storing more than one piece of information in a memory location. This is particularly effective in storing tables.

**The minimum computer size** for our purpose is approximately 1,000 words of storage. This will do only simple exchangers (liquid to liquid). Another limitation is that it is necessary to hand calculate the physical properties of the fluids and the corrected log mean temperature difference. These variables are included in the input to the computer rather than being calculated by the computer.

Those computers with approximately 4,000 words of

storage will catch, with a few exceptions, all the usual heat transfer applications. This includes services such as multi-component condensing, vaporizing and two phase flow. Also this includes several different types of exchangers such as floating head, U-tube and fixed tube sheet.

### HOW MUCH FASTER IS THE COMPUTER?

First the question must be answered how fast is it done by hand? An experienced rating engineer will average about five selections per day or approximately one every ninety-five minutes. If an engineer rates only occasionally, then he will probably average 1-4 per day depending on his experience. In an extreme case a rating will take as much as two days. A breakdown of the time required by a typical computer rating is seen in Table 1.

**TABLE 1—Typical Computer Rating Time**

| Step | Minutes |
|---|---|
| Input sheet (Fig. 1) | 3 |
| Transfer to computer | 2 |
| Computation | 1 to 5 |
| Specification sheet | 1 |
| Total | 7 to 11 |

Since there are many possible combinations of input-output equipment and computers, Table 1 is intended only as a guide. In evaluating the speed of a particular installation watch out for input-output time. This factor doesn't always receive the full consideration it deserves. In our case it requires more than half the total time.

With a little arithmetic we see a computer is approximately 8-11 times faster than the experienced rater. If a large computer is used then ratings can be made faster.

### BLOCK DIAGRAMING

A major portion of solving a problem by computer is in block diagraming. A block diagram is an outline or flowchart of the problem. From this diagram and the necessary equations, a step by step procedure can be written that the computer can follow (this is a program). This procedure is written in the language of the computer at hand.

The two main problems in programing are:

- Converting engineering data to a form that can be used by the computer.
- Including all possible situations the computer will encounter.

### SAMPLE PROGRAM

A program which will rate condensers, vaporizers and exchangers with two phase flow in several different types of equipment is quite complex. The program presented here will be a relatively simple one which can be modified to include these refinements. Also it is limited to a floating head type exchanger with two or more tube passes and a single pass shell.

The nature of the programing will depend on the computer size. With small computers it may be necessary to be repetitive to conserve memory space. For example, on a small computer each time the machine tries a new shell size it starts with two tube passes and increases in passes until pressure drop is met. On a program for a large computer it would not be necessary to start with two tube passes. By using extra instructions it could start with the number of tube passes used on the previous shell size.

### INPUT

The input format can be seen in Figure 1. For computers smaller than two thousand words this form will be slightly changed. For these smaller computers the physical properties, heat load check and corrected log mean temperature difference are calculated by hand and included in the input.

### FLUID IDENTIFICATION AND PROPERTIES

The first computer step after the input is loaded is to identify the fluids on the shell and tube sides. A block diagram of the fluid identification and properties subroutine is given in Figure 2. After identification the properties are assembled and transferred to where they will be used in the program. In order to save valuable memory space this same routine is used for both the shell and tube sides.

A fluid is identified by a search of the input storage. For example if there is a zero in the flow input for

$$c = 0.681 - 0.308\ S.G. + t_a\ (0.000815 - 0.000306\ S.G.) \quad (1)$$

$$K\ (c\mu/K)^{1/3} = 0.15\ \mu^{1/3} \quad (2)$$

$$\text{Gas } \rho = \frac{M.W.\ P_o}{10.7\ Z\ (460 + t_a)} \quad (3)$$

$$\text{(Shell) } \Delta t_s = t_{s1} - t_{s2}$$
$$\text{(Tube) } \Delta t_c = t_{c2} - t_{c1} \quad (4)$$

$$Q = WC\Delta t \text{ or } Q = W\Delta H \quad (5)$$

**FIGURE 2—This program will check the input heat load.**

water then the computer knows that it is some other substance. Thus it in effect answers the question, "Is it water?"

There are three sources from which this routine can assemble properties. They are as follows:

- Input data
- By calculation
- Within the sub-routine

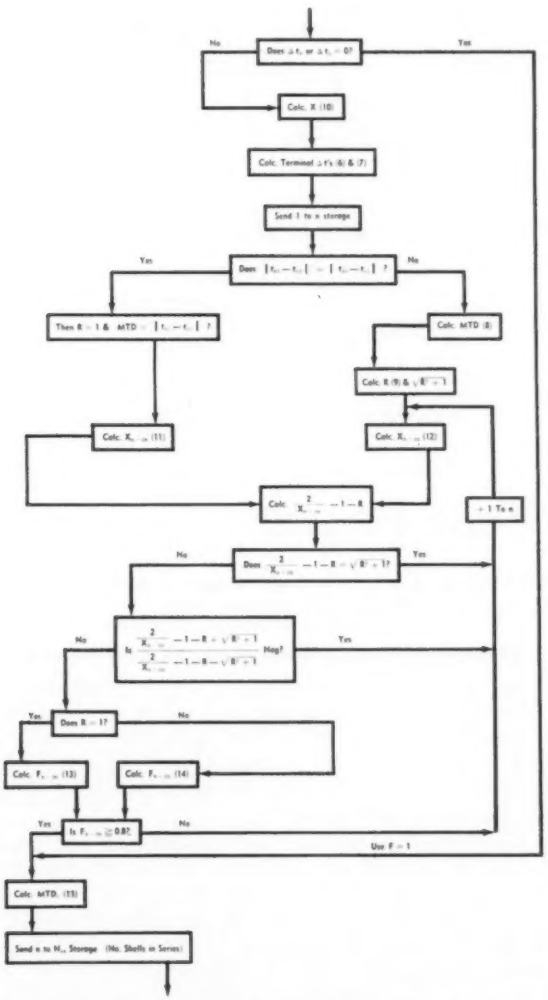
Those properties requiring excessive memory capacity to calculate are included in the input. An example of this is liquid viscosity. Properties which are constant over a wide temperature range are stored within the sub-routine. An example of this is the specific heat of water.

If the process stream is identified as oil, the specific heat is calculated[1] from Equation (1) in Figure 2. This equation is based on a characterization factor of 11.8. If the oil has a significantly different factor a multiplier must be used with Equation (1). The multiplier can be obtained from the expression $0.055K + 0.35$ where K is the characterization factor.

**It is not necessary** to supply a thermal conductivity value to the input for the previously mentioned oil. By means of Equation (2) the function $K(c\mu/k)^{1/3}$ for heat transfer can be calculated. It is necessary to supply only the viscosity. This relationship is based on thermal conductivity data from Figures T-11 and T-11 A in the 1954 addenda to TEMA.[2] The coefficient of 0.15 used in the equation is an average value. The lighter hydrocarbons through hexane reflect a coefficient of 0.148. From Hexane through 50° API oil the coefficient is 0.152. The coefficent decreases with gravity to a low of 0.145 for 37° API and heavier oils. This use of an average coefficient is justified when the large variation of thermal conductivities in the literature is considered.

After the properties are assembled they are transferred to where they will be used. For instance the specific heat is sent to the heat load check and also the heat transfer coefficient routine.

**This program** is based on the premise the heat load is supplied by an external source. The machine will rough check the input heat load rather than supply it. If it is desired for the machine to calculate and supply its own heat load then only a slight modification in the program is necessary. After the heat load is calculated




$$|T_{s1} - T_{c2}| \quad (6)$$

$$|T_{s2} - T_{c1}| \quad (7)$$

$$MTD = \frac{GTD - LTD}{Ln(GTD/LTD)} \quad (8)$$

$$R = \Delta t_s/\Delta t_c \quad (9)$$

$$X = \frac{\Delta t_c}{|T_{s1} - T_{c1}|} \quad (10)$$

$$\text{When } R = 1 \quad (11)$$

$$X_{n-2n} = \frac{X}{n - nx + x}$$

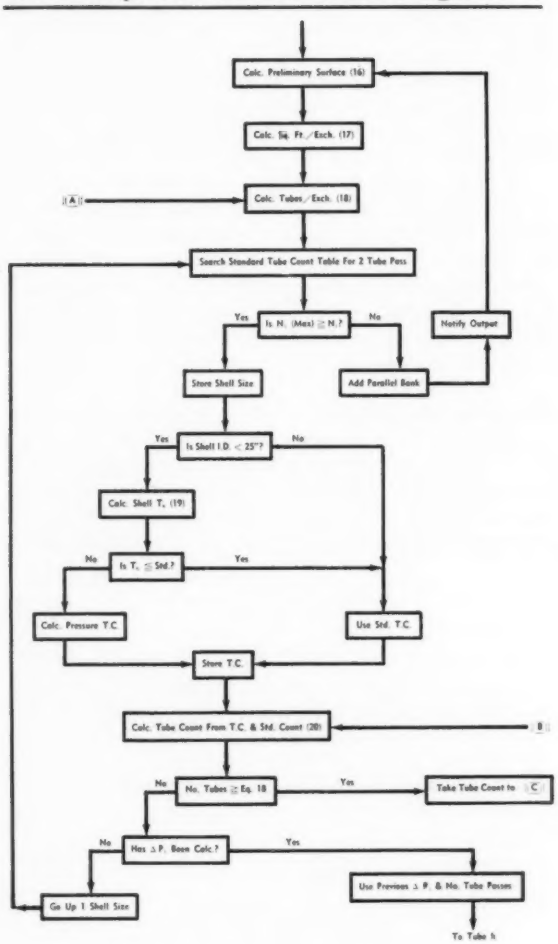
$$X_{n-2n} = \frac{1 - \left(\frac{1 - RX}{1 - X}\right)^{\frac{1}{n}}}{R - \left(\frac{1 - RX}{1 - X}\right)^{\frac{1}{n}}} \quad (12)$$

$$\text{When } R = 1 \qquad F_{n-2n} = \frac{1.414 \left(\frac{X_{n-2n}}{1 - X_{n-2n}}\right)}{Ln\left(\frac{\frac{2}{X_{n-2n}} - 1 - R + \sqrt{R^2 + 1}}{\frac{2}{X_{n-2n}} - 1 - R - \sqrt{R^2 + 1}}\right)} \quad (13)$$

$$F_{n-2n} = \frac{\frac{\sqrt{R^2 + 1}}{R - 1} Ln\left(\frac{1 - X_{n-2n}}{1 - RX_{n-2n}}\right)}{Ln\left(\frac{\frac{2}{X_{n-2n}} - 1 - R + \sqrt{R^2 + 1}}{\frac{2}{X_{n-2n}} - 1 - R - \sqrt{R^2 + 1}}\right)} \quad (14)$$

$$MTD_c = MTD(F) \quad (15)$$

**FIGURE 3—The program for corrected mean temperature difference should not be used if you are limited in memory space.**


Calc. Preliminary Surface (16)
Calc. Sq. Ft./Exch. (17)
Calc. Tubes/Exch. (18)
Search Standard Tube Count Table For 2 Tube Pass
Is N. (Max) ≥ N.?
Yes
No
Notify Output
Store Shell Size
Add Parallel Bank
Is Shell I.D. < 25"?
Calc. Shell T. (19)
Is T. ≤ Std.?
Calc. Pressure T.C.
Use Std. T.C.
Store T.C.
Calc. Tube Count From T.C. & Std. Count (20)
No. Tubes ≥ Eq. 18
Take Tube Count to C
Has ΔP. Been Calc.?
Use Previous Δ P. & No. Tube Passes
Go Up 1 Shell Size
To Tube h

$$At = \frac{Q}{MTD_c\ Umax} \tag{16}$$

$$\text{Sq. Ft./Exch} = A_t/N_{es}\ N_{ep} \tag{17}$$

$$N_T = A/(\text{Sq. In./Ft.})\ (L) \tag{18}$$

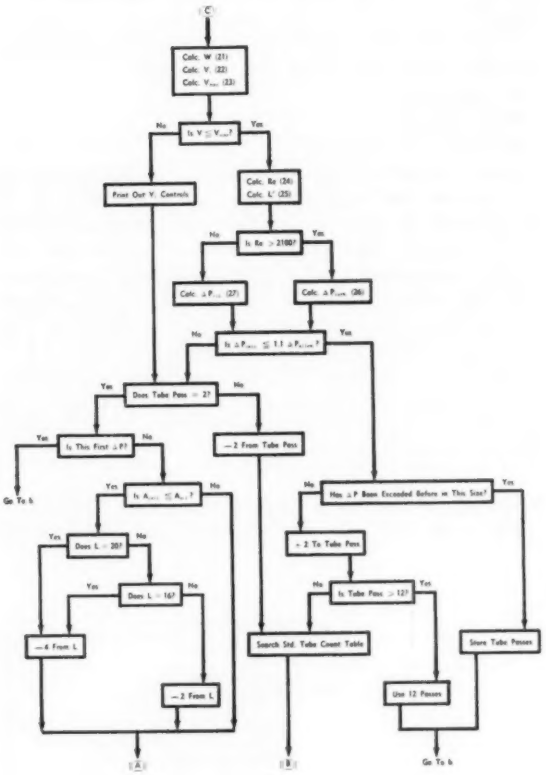
$$T_k = \frac{(P)\ (r_s)}{15{,}000 - 0.6\ P} + \text{Corrosion Allowance} \tag{19}$$

$$\text{Count} = \left(\frac{\text{Pressure Tube Circle}}{\text{Standard Tube Circle}}\right)^2 \tag{20}$$

**FIGURE 4—The function of this routine is to keep track of the exchanger arrangement and the shell size. Points A, B, and C refer to Figure 5 also.**

by means of Equation (5) it is checked against the input head load. If the difference is more than 10 percent then the calculated head load is printed out. Then the flow or temperature range can be changed in the input accordingly. With a large computer this change in input could be programmed to be done automatically.

When the heat load for condensing steam is checked an average latent heat of 890 Btu/lb is used. This value will check within 10 percent of the heat load for steam pressures ranging from atmospheric to 300 psi.




$$W = W_t\ N_p/N_t\ N_{ep} \tag{21}$$

$$V_t = .051\ W/d_i^2\rho \tag{22}$$

$$Vmax = \frac{\sqrt{(\text{To Be Inserted})}}{\sqrt{\rho}} \tag{23}$$

$$Re = 6.31\ W/d_i\mu \tag{24}$$

$$L' = (L + 5.55\ d_i)\ N_p\ N_{es} \tag{25}$$

$$\Delta P_{turb.} = \frac{6.38\ W^{1.8}\ L'\ \mu^{0.2}}{10^7\ d_i^{4.8}\ \rho\ (\mu/\mu_w)^{0.14}} \tag{26}$$

$$\Delta P_{vis.} = \frac{4.08\ W\mu L'}{10^5\ d_i^4\ \rho\ (1.1\ \mu/\mu_w)^{0.25}} \tag{27}$$

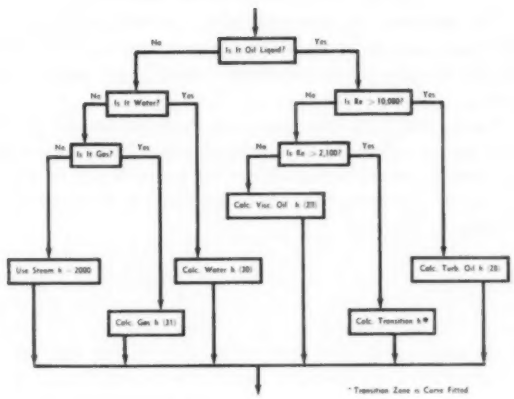
**FIGURE 5—A relatively large amount of logic is required for calculating the tube side pressure drop.**

## CORRECTED MEAN TEMPERATURE DIFFERENCE

The simplest way of obtaining a mean temperature difference (MTD) correction by hand is by using the curves in TEMA.[2] The machine procedure as can be seen in Figure 3 is not as easy. Unless one can spare the memory space it is debatable whether putting it on the machine is advisable.

Fortunately we do not need six different equations for one to six shell pass correction factors. We can use one equation if we modify the X variable for each case. Usually we can calculate X, for a desired number of shells in series, by Equation (12).[5] Then this X is inserted in Equation (14)[3,4] to obtain F.

As can be seen in Figure 3 the first time the correction factor F is equal to or greater than 0.8 then an exit


Is It Oil Liquid?
Is It Water?
Is It Gas?
Is Re > 10,000?
Is Re > 2,100?
Calc. Visc. Oil h (29)
Use Steam h = 2000
Calc. Water h (30)
Calc. Turb. Oil h (28)
Calc. Gas h (31)
Calc. Transition h*
* Transition Zone is Curve Fitted

Turbulent Zone

$$h_{io} = \frac{0.435\ Re^{0.8}}{d_o} K \left(\frac{C\mu}{K}\right)^{1/3} \left(\frac{\mu}{\mu_w}\right)^{0.14} \quad (28)$$

Viscous Zone

$$h_{io} = \frac{13.1\ Re^{1/3}}{d_o} \left(\frac{d_i}{L}\right)^{1/3} K \left(\frac{C\mu}{K}\right)^{1/3} \left(\frac{\mu}{\mu_w}\right)^{0.14} \quad (29)$$

Transition Zone Is Curve Fitted

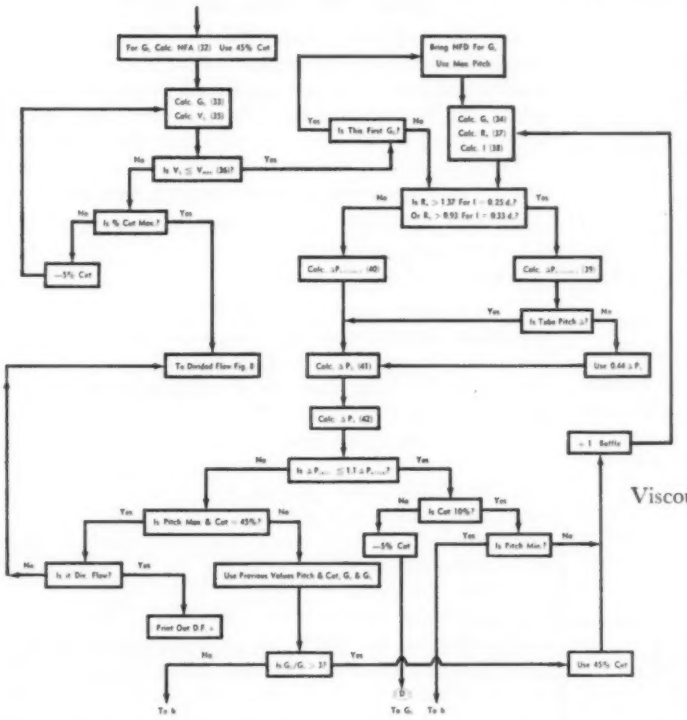
Water

$$h_{io} = \frac{160}{d_o} (1 + 0.1\ t_A)\ V^{0.8}\ d_i^{0.8} \quad (30)$$

Gas

$$h_{io} = \frac{1.53\ CW^{0.8}}{d_o\ d_i^{0.8}} \quad (31)$$

**FIGURE 6—The tube side film coefficient depends upon the type of flow within the tubes.**


For G, Calc. NFA (32) Use 45% Cut
Calc. G, (33)
Calc. V, (35)
Bring NFD For G, Use Max Pitch
Is This First G,?
Calc. G, (34)
Calc. R, (37)
Calc. f (38)
Is V, ≤ Vmax (36)?
Is % Cut Max.?
—5% Cut
Is R, > 1.37 For f = 0.25 & ?
Or R, > 0.93 For f = 0.33 & ?
Calc. ΔP (40)
Calc. ΔP (39)
Is Tube Pitch Δ?
To Divided Flow Fig. 8
Calc. Δ P, (41)
Use 0.44 Δ P
Calc. Δ P, (42)
+ 1 Baffle
Is ΔP ≤ 1.1 ΔP?
Is Pitch Max. & Cut = 45%?
Is Cut 10%?
—5% Cut
Is Pitch Min.?
Is it Div. Flow?
Use Previous Values Pitch & Cut, G, & G,
Print Out D.F.
Is G,/G > 3?
Use 45% Cut
To h
To G,
To h

$$NFA = \pi r_s^2 - 0.785\ N_t\ d_o^2 \quad (32)$$

$$G_L = 0.04\ W_s/(NFA)\ (\%\ Cut) \quad (33)$$

$$G_x = 0.04\ W_s/(NFD)\ (P) \quad (34)$$

$$V_L = G_L/\rho_s \quad (35)$$

$$Vmax = 40/\sqrt{\rho_s} \quad (36)$$

$$R_x = d_o\ G_x/\mu_s \quad (37)$$

$$l = \text{Tube Pitch} - d_o \quad (38)$$

$$\text{Turbulent } \Delta P_x = 0.000124\ \frac{\mu^{0.2}\ G_x^{1.8}}{l^{0.2}\ \rho_s} N\ (B + 1) \quad (39)$$

$$\text{Viscous } \Delta P_x = 0.0000522\ \frac{\mu\ G_x}{l\rho_s} N\ (B + 1) \quad (40)$$

$$\Delta P_L = G_L^2 B/5950\ \rho_s \quad (41)$$

$$\Delta P_s = \Delta P_x + \Delta P_L \quad (42)$$

**FIGURE 7—This program for shell side pressure drop is designed to discover special cases promptly. Point D refers to a supplemental program shown in Figure 8.**

is made and the corrected MTD calculated. From the $X_{n-2n}$ that is used in computing the correction factor it is known how many shells in series are to be used. For example if $X_{4-8}$ is used then four shells in series with a total of 8 or more tube passes is required.

The complexity of this routine partially stems from a built-in prevention of division by zero. If a division by zero occurs the machine will overflow. For example, in Equation (14) a division by zero will occur when $(2/X)\text{-}1\text{-}R = \sqrt{R^2 + 1}$ or $R = 1$. In the first case this cannot occur for a one shell MTD correction factor greater than 0.8. Therefore when the machine discovers this case it develops an X parameter for two shell passes and $(2/X)\text{-}1\text{-}R$ will no longer equal $\sqrt{R^2 + 1}$. When $R = 1$, $X_{n-2n}$ is calculated by Equation (11)[5] and used in Equation (13).

## SELECTION OF SIZE AND ARRANGEMENT

The function of the routine shown in Figure 4 is to keep track of the exchanger arrangement and the shell size.

By means of Equation (16) the preliminary surface is calculated. Then the surface per exchanger is calculated from Equation (17). In the first trial, one bank of exchangers is used. $N_{ep}$ (number of exchangers in parallel) will be one. $N_{es}$ (number in series) will be as determined from the MTD program.

After the number of tubes is calculated by Equation (18) the machine will search the standard 2 tube pass counts until a shell size with the same or more tubes is found.

## Use Computers to Select Exchangers . . .

**Some companies** have the equipment to handle larger exchangers than others. Thus we must have some way of limiting the shell size. This is done by storing in the memory the 2 tube pass count for the largest acceptable shell size. Then whenever the shell size is changed the machine tests to make sure that the number of tubes is less than this maximum count ($N_t$ max.). If the tube count is greater than $N_t$ max. then a parallel bank of exchangers is added, thus reducing the shell size.

The first surface selected will be either the same or smaller than the final selection. The purpose of this is to eliminate the possibility of a selection that satisfies all conditions but is oversurfaced. This could happen if we started with a larger surface than the final selection. Starting with a smaller surface is accomplished by specifying in the input a U max. U max. is the maximum acceptable over-all heat transfer coefficient. If in doubt about what to specify, use a U that is abnormally high or use the reciprocal of the total fouling factor.

Exchanger shells that are smaller than 25-inch ID are manufactured from pipe. The tube counts used in the computer are based on the shell thickness shown in TEMA[2]—page 9. If the shell thickness calculated by Equation (19)[7] exceeds the standard then the tube circle is reduced accordingly. When this is the case the new tube count is obtained by Equation (20). The case of shells larger than pipe size is simpler. For all pressures we can keep a standard tube circle and shell ID and let the OD fall where it will.

### TUBE SIDE PRESSURE DROP

The program for the tube side pressure drop is illustrated in Figure 5. As can be seen it involves a relatively large amount of logic.

Each time the tube count or number of tube passes is changed the velocity is checked to make sure it is not too high. The maximum allowable velocity is calculated from Equation (23). If the fluid is clean the value to be used in the numerator will depend on the tube material used. A value of approximately 3500 can be used for admiralty tubes.

**The Reynolds number** is calculated and checked to see if the flow is turbulent or viscous. If the flow is viscous, Equation (27) is used. If the flow is turbulent, Equation (26) is used. Both of these equations are based on the Fanning equation. The friction factor incorporated in the viscous equation is simply $f = 16/Re$. The friction factor used for turbulent flow is $f = 0.048/Re^{0.2}$. A safety factor of 20 percent is used to take care of fouling and the effect of possible over tolerance of tube wall.

To take into consideration pressure drops on the tube side other than that inside the tube, Equation (25) is used. This gives an effective tube length which is inserted into Equation (25), or (27) if the flow is viscous.

**This program** is set up on the basis that the maximum number of tube passes is 12. If the calculated pressure drop is still under the allowable with 12 tube passes, the computer proceeds to the tube side heat transfer coefficient section.

### TUBE SIDE FILM COEFFICIENT

For purposes of heat transfer we will consider the turbulent zone to be for a Reynolds number greater than 10,000. In this zone the Sieder and Tate[6] equation is used.

When the Reynolds number is between 2100 and 10,000 it is called the transitional zone. In this zone one equation is not sufficient. Here we must resort to breaking the heat transfer data into intervals to fit the curves[2] as close as possible.

Equation (29) is used when the Reynolds number is less than 2100. Each rating that is computed in this zone should be examined carefully. This equation in some cases is conservative because it doesn't include the effects of natural circulation and turbulence at the tube ends.

Simplified equations are used for water and gas. These have the advantage of using relatively few physical properties. This saves time on compiling input data.

### SHELL SIDE PRESSURE DROP

First the computer assembles the information necessary to compute the cross flow velocity and the baffle window velocity. From storage it brings the net free distance (NFD) for cross flow. The net free area (NFA) for baffle window flow is calculated from Equation (32).

The program is designed to discover special cases promptly. The special cases stem from the following:

- Low operating pressure on a vapor
- Abnormally high flow
- Abnormally low flow

The machine starts with maximum baffle pitch and maximum percent cut. The maximum allowable baffle pitch is that specified in TEMA[2] and will vary with tube OD. For most cases the maximum percent cut is approximately 45 percent. The machine starts with this baffeling arrangement and calculates the pressure drop. If the pressure drop is excessive the machine will go into the divided flow portion of the routine. For the same pitch and cut, divided flow will reduce the shell side pressure drop by a factor of approximately 8. Thus the computer immediately tests for the first and second cases just discussed.

The machine tests for case 3 as follows: The machine starts reducing the baffle cut in 5 percent increments, calculating the pressure drop each time. When the baffle cut is reduced to 10 percent, the machine will add baffles one at a time. Baffles are added until minimum baffle pitch is encountered (⅕ of the shell ID down to 2 inches). When minimum baffle pitch is reached, the low flow case is discovered without trying every different possible combination of pitch and cut.

Without modification, this procedure, for a normal case, would give a low percent cut and wide baffle pitch. This type of baffling will also give a relatively low heat transfer coefficient for a given pressure drop.

**For small computers,** where memory space is at a premium, it is necessary to approximate the region of pitch and cut which will give optimum heat transfer for a given pressure drop. This is done by limiting the ratio of $G_1/G_x$ to less than three.

In large computers, where memory space is not a problem, it is possible to choose a pitch and cut combination which gives the highest heat transfer. To arrive at the

optimum heat transfer coefficient use is made of the fact that the shell film coefficient is directly proportional to the product of $G_x$ and $G_l$. There is one combination of pitch and cut which will give a higher product of $G_x$ and $G_l$ than any other. After the computer finds all the baffling combinations that meet pressure drop, the one which gives the highest velocity product is selected for use.

It is necessary to place a restriction on the shell side velocity. This is done in order to eliminate velocities that would set up damaging vibration. This is more of a problem in U-tube exchangers than it is in floating head and fixed tube sheet types. The velocity around the baffle is the most critical and usually has a higher value than the cross velocity. The velocity around the baffle is limited by Equation (36).

The shell side pressure drop equations are based on presentations of Chilton and Genereaux[8] and Colburn[9].

## SHELL FILM COEFFICIENT

Figure 9 is the block diagram for the subroutine of the shell film coefficient. Equation (44) is based on work of Donohue.[10] This is the best published correlation available at this time.

## CALCULATION OF U AND SURFACE

This sub-routine is illustrated in Figure 10. The over-all U is calculated from the sum of the heat transfer resistances shown in Equation (47). The calculated surface (48) is compared with the actual surface (49). If the actual surface is more, then the selection is printed out. If the surface is insufficient the computer returns to point A in Figure 4.

## OUTPUT

Figure 11 illustrates the output format. Most of the information is of a mechanical nature. The film coefficients, Reynolds numbers and tube velocity are not necessary but come in handy in case of trouble.

## MODIFICATIONS FOR SPECIAL CASES

Whenever the program is modified or added to, it is necessary to "debug" it. This is done by putting a problem in the computer and checking the new portion step by step. It is convenient to be able to specify to the input the tube passes, shell diameter and baffle pitch and cut in this case.

Sometimes the selection made by the computer is not the most economical. To account for this, it is necessary to be able to specify the new arrangement to the machine. For example if there is a very low flow it is sometimes cheaper to use two exchangers in series rather than one. The machine would normally use one exchanger. After this is done it is necessary to be able to specify two exchangers in series to the computer input.

The program presented here can be modified to include such ratings as two pass shells, condensers, reboilers and heaters. By modification it can do fixed tube sheets, U-tubes, double pipe, fin tubes and kettles.

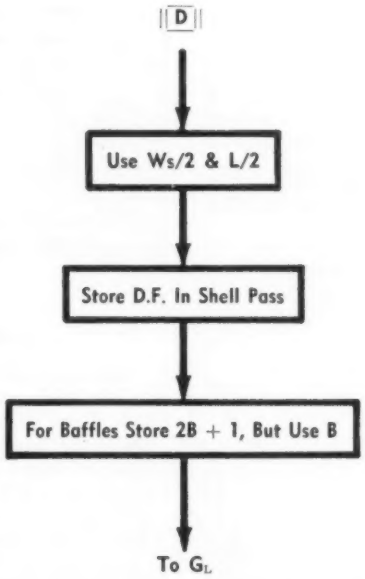
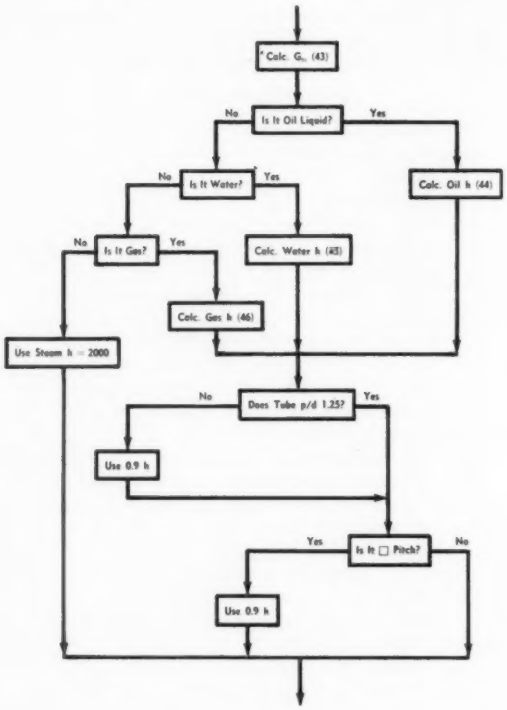



**FIGURE 8—If the pressure drop in the shell is excessive, the machine will go into the divided flow portion of the routine shown here.**

## SYMBOLS USED

A — Exchanger surface, sq. ft.
B — Number of baffles
C — Specific heat, Btu/(lb.) (F)
$d_i$ — Tube ID, in.
$d_o$ — Tube OD, in.
F — MTD correction factor
$G_t$ — Tube mass velocity, lb/(ft.²) (sec.)
$G_x$ — Shell crossflow mass velocity, lb/(ft.²) (sec.)
$G_l$ — Shell longitudinal mass velocity, lb/(ft.²) (sec.)
$G_m$ — Geometric mean velocity, lb./(ft.²) (sec.)
GTD — Greater temperature difference, °F
$h_{io}$ — Inside film coefficient, Btu/(hr.) (sq. ft.) (°F)
$h_o$ — Outside film coefficient, Btu/(hr.) (sq. ft.) (°F)
$\Delta H$ — Enthalpy change, Btu/lb.
k — Thermal conductivity, Btu/(hr.) (°F) (sq. ft./ft.)
K — Characterization factor
l — Tube pitch—tube OD, in.
L — Tube length, ft.
L′ — Effective tube length, ft.
LTD — Lesser temperature difference, °F
MTD — Mean temperature difference, °F
$MTD_c$ — Mean temperature difference corrected, °F
MW — Molecular weight
n — Number of shell passes
N — Number of rows in crossflow
$N_{es}$ — Number of exchangers in series
$N_{ep}$ — Number of exchangers in parallel
NFA — Net free area, sq. in.
NFD — Net free distance in.
$N_p$ — Number of tube passes
$N_t$ — Number of tubes
$p_o$ — Operating pressure, psi.
$p_d$ — Design pressure of shell, psi.
P — Baffle pitch, in.
$\Delta P_t$ — Tubeside pressure drop, psi.
$\Delta P_x$ — Shell crossflow pressure drop, psi.
$\Delta P_l$ — Shell longitudinal pressure drop, psi.
$\Delta P_s$ — Shell total pressure drop, psi.
Q — Heat duty, Btu/hr.
$r_s$ — Shell inside radius, in.
R — Parameter for MTD correction
$r_{fi}$ — Inside fouling (sq. ft.) (hr.) (°F)/Btu
$r_{fo}$ — Outside fouling (sq. ft.) (hr.) (°F)/Btu
$R_e$ — Reynolds number
S.G. — Specific gravity
$t_a$ — Average temperature, °F
$\Delta t$ — Temperature range, °F
$T_{s1}$, $T_{s2}$ — Shell inlet and outlet temperature, °F
$T_{c1}$, $T_{c2}$ — Channel inlet and outlet temperature, °F
$T_k$ — Shell thickness, in.
T.C. — Tube circle or bundle diameter, in.
U — Over-all heat transfer coefficient, Btu/(hr.) (sq. ft.) (°F)



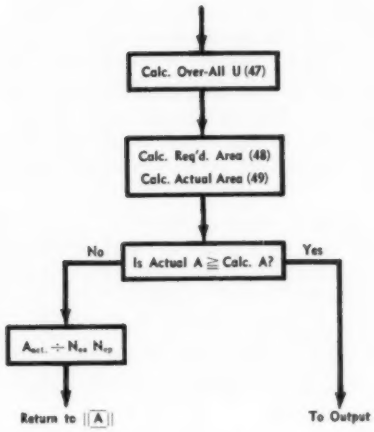

$$G_m = \sqrt{(G_x)\,(G_L)} \qquad (43)$$

$$h = \frac{64\,G_m^{0.6}}{d_o^{0.4}\,\mu^{0.6}} \cdot K\left(\frac{C\mu}{K}\right)^{1/3}\left(\frac{\mu}{\mu_w}\right)^{0.14} \qquad (44)$$

$$\text{Water } h = 247\,\frac{(1 + 0.0067\,t_a)}{d_o^{0.4}\,\rho^{0.6}}\,G_m^{0.6} \qquad (45)$$

$$\text{Gas } h = 29\,\frac{CG_m^{0.6}}{d_o^{0.4}} \qquad (46)$$

**FIGURE 9—The subroutine of the shell film coefficient is based on work of Donohue.[10]**




$$U = 1/h_o + 1/h_{io} + r_c \qquad (47)$$

$$A_{calc.} = \frac{Q}{MTD_c\,U} \qquad (48)$$

$$\text{Actual } A = (N_{es}\,N_{ep}\,N_t\,L)\ \text{(Sq. In./Ft.)} \qquad (49)$$

**FIGURE 10—The overall U is calculated from the sum of the heat transfer resistances. Point A refers back to Figure 4.**

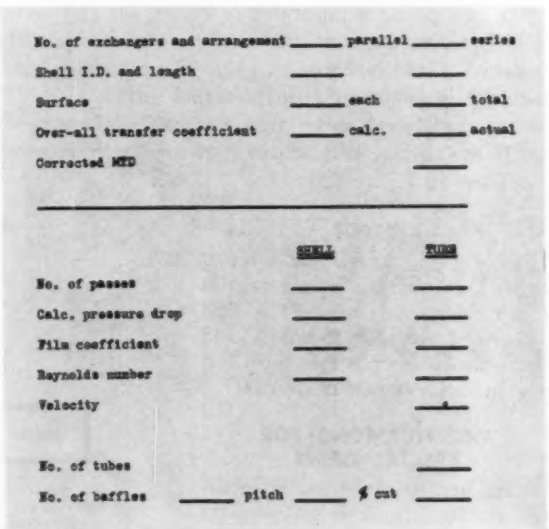

No. of exchangers and arrangement ____ parallel ____ series
Shell I.D. and length
Surface ____ each ____ total
Over-all transfer coefficient ____ calc. ____ actual
Corrected MTD
No. of passes
Calc. pressure drop
Film coefficient
Reynolds number
Velocity
No. of tubes
No. of baffles ____ pitch ____ % cut

**FIGURE 11—The film coefficients, Reynolds numbers and tube velocity are not necessary in the output form, but they come in handy in case of trouble.**

V — Velocity, ft./sec.
W — Flow rate, lb./hr.
X — Variable for MTD correction
Z — Compressibility factor
$\mu$ — Viscosity, centipoise
$\mu_w$ — Viscosity at the wall, centipoise
$\rho$ — Density, lbs/cu. ft.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## About the Author


**Dale L. Gulley** is head of the Rating Department of the heat exchanger division for Western Supply Co., Tulsa. He is responsible for the rating, coordination, and scheduling of heat transfer designs. Holder of a B.S. degree in chemical engineering from Oklahoma State University, Gulley has had experience as a design engineer for Phillips Petroleum Co., process engineer for Phillips Chemical Co., and rater and computer programer for Coynco Products, Inc. He is a member of AIChE.

# Operator's Handbook for Gasoline Plants

## PART 10—Fire fighting and emergency systems: One of a series that simplifies operations and equipment for the new and experienced operator

**Manufacturing Department,**
**Tennessee Oil Refining Co.**
A Division of Tennessee Gas Transmission Co., Houston

EVERY NATURAL GASOLINE plant has installed facilities to help prevent explosions and combat fires. These facilities contribute greatly to safe and orderly operation. They are not necessarily the same for each plant, but they all are installed for the same purpose—to prevent injury to personnel and damage to plant facilities.

What causes fires? The answer is best illustrated by the fire triangle (Figure 53). The sides of the triangle are fuel, oxygen and heat. If any one of these sides is removed, then no fire can occur.

Further, the fuel and air must be mixed in the right proportion to make a fire of oxygen and fuel. And finally, some portion of the mixture must be brought to ignition temperature. To extinguish any fire, all that is necessary is to remove any one of the three ingredients—fuel, heat or oxygen. Lowering the concentration of any of these ingredients below the minimum requirements will also extinguish and prevent a fire.

Most plants use four means of protection.

1. Fire fighting systems
2. Snuffing and smothering systems
3. Bypass systems
4. Shut-down systems

### FIRE FIGHTING SYSTEMS

In most plants adequate fire plugs are strategically placed throughout the plant. The main water lines are also looped. All fire water lines are 4 inches or greater in size. Block valves are placed so that sections of the main line can be isolated in case of a break. Thus, in most cases, water is available at all times during repairs to the line.

Most plants are equipped with not less than 500 gallon-per-minute water pump (gasoline and gas-driven) discharging at a minimum pressure of 125 psi. The battery of the engine is equipped with a trickle charger to insure readiness of the firewater pump at all times.

A four-hour supply of water for the pump is made available through a water storage tank or a reservoir of some type. In addition to the water supply, a minimum of 150 gallons of 3 percent liquid foam can be placed in the plant.

For plants located in the vicinity of a town with fire equipment available, the hose threads on the fire trucks should adapt to the plugs in the plant. In all new plants advance contact should be made with the local fire department to insure that adapters are available for this purpose.

Metal hose boxes are placed in and around the process area and the housing area. These hose boxes are equipped with 1½-inch hose that is latex-coated to resist rot. A fog nozzle and foam nozzle are also placed in each box. The hose is permanently hooked up to the fire plug. With this arrangement, the plug is opened, pump started, and the fire fighter proceeds to the fire with the hose.

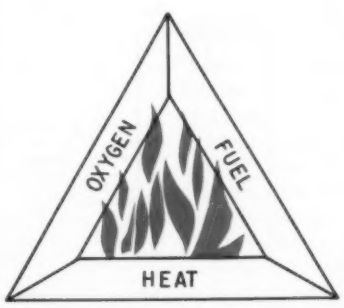



**FIGURE 53—Fire triangle shows what's necessary for a fire to take place.**

There are two types of hookups available. One of these allows the injection of liquid foam at the hydrant. In the other, the foam must be carried to the foam nozzle at the end of the hose where a 1-inch pick-up tube is utilized to pull the liquid into the nozzle. The first of these is more desirable since this eliminates the need for foam to be carried to the end of the hose and gives the

person handling the hose more freedom of movement. This also allows the men who are opening foam to be farther away from the heat of the fire. Figure 54 shows a typical arrangement.

## HAND EXTINGUISHERS

An individual study should be made of each new plant and any existing plant that may be purchased to determine the quantity and proper spacing of hand fire extinguishers in the process area. Thirty-pound dry powder units are usually bought for this area. They are installed on the pipe supports at a height of approximately 3 to 4 feet. A 3 foot high section around such supports would be painted red, beginning approximately 3 feet from its base. The hand extinguisher should be hung in the center of the red area. This provides quick identification from any point within view, making it possible for a person to glance through the process area and see where the extinguisher is located. Painting the columns eliminates the frustration and delay experienced when the location of an extinguisher is hidden behind a column. Figure 55 shows a typical installation. Table 1 matches the extinguisher to the type of fire.

**Dry Powder Extinguisher.** This is the most common means of providing a good, inexpensive fire fighting tool that will cover a large territory. Most plants have the dry powder type hand extinguishers hanging in various spots throughout the plant. These extinguishers are filled with a dry powder that consists of soda and other materials to make it flow freely. When the dry chemical is spread over the fire, the high temperature of the fire breaks the soda down and releases carbon dioxide. This carbon dioxide, being heavier than air, settles over the fuel, thus reducing the amount of air that can get to the fire. Consequently, the fire is extinguished. The carbon dioxide may be thought of as a blanket that is placed between the fire and the air.

With this type of extinguisher, there are two important points to remember:

1. The amount of powder that is available for use in each extinguisher is relatively small—about 15 seconds will empty the average 20 pound extinguisher.
2. The powder should be directed to the base of the flame from an upwind position using a fanning movement.
3. When any hand extinguisher has been used, it must be recharged with dry chemical and a new cartridge installed before it is put back in its proper location.

**Foam Fire Extinguisher.** This extinguisher contains two different chemical solutions which are inert as long as each remains in its own compartment. When mixed, a pressure is created on the inside of the container, and frothy foam comes out of the hose. This foam, when placed on a fire, acts like a flexible, insulating blankets that cuts off the air. The foam blanket insulates because it is made up of tiny bubbles of carbon dioxide, each enclosed in a tough liquid film.

The foam works best if it is applied in such a way that the blanket isn't broken up. If it is directed onto a flammable liquid fire in a tank or open container, bank it off the walls so it can spread slowly over the surface. Otherwise, let the foam fall gently onto the burning liquid surface.

On spill fires, start at one side of the burning area and lay a blanket that will progressively cover more and more of the blazing area until all of it is covered. If the foam blanket is broken a flammable liquid surface is exposed which will catch fire again.

Enough pressure is exerted when the two solutions mix so that the extinguisher throws a stream about 30 to 40 feet. The extinguisher will empty itself in about a minute, so it's important that it is not started until the fire is reached. Since foam corrodes metal surfaces, it should be cleaned quickly from machines. Flooding with water will break up the banket.

Ordinary foam freezes because it is a water solution, and consequently should not be left in an unheated spot. Special foam extinguishers are available for freezing temperatures. Foam is effective on wood, paper, rubbish and other deep-seated fires, but it is best on flammable liquid fires. *Do not use it on live electrical fires;* it is a conductor of electricity.

**Soda Acid Fire Extinguisher.** This extinguisher has a cooling and quenching action which eliminates the heat of the fire. It is intended for fires in solids such as wood, paper, rubbish and cloth.

The soda acid extinguisher usually contains two and one-half gallons of water with ordinary baking soda dissolved in it. Hanging inside the top of the cylinder is a little cage holding a small bottle of sulfuric acid. A lead stopple in this bottle keeps the acid from spilling unless the extinguisher is tipped. For this reason a soda acid extinguisher must always be carried upright until ready for use.

To operate this type of extinguisher, it is turned upside down. The stopple drops from the bottle, and the acid mixes with the water in which soda bicarbonate has been dissolved. This mixture generates $CO_2$ gas that rises through the water, building the pressure necessary to force the water from the hose. Direct the stream of water which emerges from the hose nozzle into the base of the fire. If a stream of water doesn't start in a few seconds, step away from the extinguisher. The cylinder may burst if the hose is clogged.

The stream of water from this extinguisher has a range of about 40 feet. Since it will last a little less than a minute, it must be used effectively from the start.

**Gas Cartridge Extinguisher.** This extinguisher looks much like the soda-acid. It also operates the same way except that after being inverted it must be bumped on the floor. This action drives a pin into the cartridge, releasing the compressed gas which forces water through the hose. The extinguisher may contain either plain water or water with an antifreeze chemical added.

This extinguisher is suitable for use on Class A fires in ordinary combustibles and Class B fires in flammable liquids. It should not be used for fires in electrical equipment.

**Carbon Dioxide Fire Extinguisher.** Carbon dioxide puts out fires because it shuts off the supply of air and oxygen. The extinguisher is heavy, and there's a good reason for its rugged construction. It contains carbon dioxide gas at a pressure of close to 800 pounds, so it is built similar to other compressed gas containers.

This extinguisher does its best job in the first few seconds when the pressure is highest. If it is released too soon or aimed wrong, the effectiveness of this extinguisher is lost. Carbon dioxide works

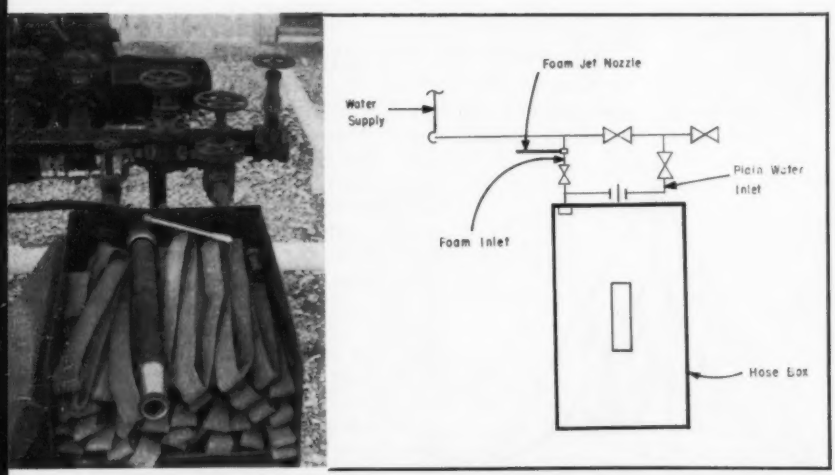



**FIGURE 54—Scheme for injecting foam at the water hydrant instead of at the end of the hose.**

**TABLE 1. Matching the Extinguisher to the Fire**

| CLASSIFICATION OF FIRE | Extinguishing Method | Approved Extinguisher |
|---|---|---|
| **1. Class "A" Fire** Fire burns deep into wood and other combustible solids such as paper, cloth, trash, etc. Even after the flames are out, it may keep smoldering and reflash. Water penetrates and cools deep down. Extinguishers which do not contain water can be used also to hold fire in check, but a wetting agent will have to be used before embers can completely be extinguished. | Cooling action | Pump tank water soda-acid. |
| **2. Class "B" Fire** With this type of fire only the vapors at the surface are burning. This is what occurs when oil, paint, grease, tar, gasoline, etc. burn. When the flame is out, the fire is out. Water should not be used, as most flammable liquids in this class will float on water and continue burning. | Smothering action | Dry chemical carbon dioxide foam. |
| **3. Class "C" Fire** Class "C" fires are electric fires. Most extinguishers with smothering action are non-conductive and safe to use in this type of fire. There is danger of electrical shock with the water type extinguisher. | Smothering action | Dry chemical carbon dioxide. |

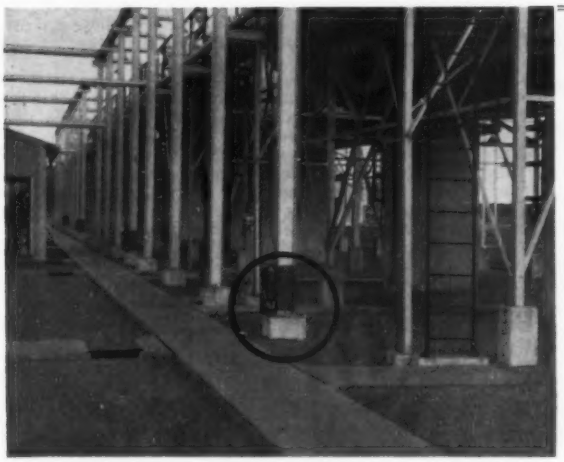


**FIGURE 55—Hand extinguishers can be spotted quickly in a plant from the special painting of columns where they are mounted.**

best at a distance of from 5 to 8 feet. It is especially good on electrical fires and fires in flammable liquids like gasoline or solvents because it smothers well and doesn't conduct electricity.

If an area is filled with this gas, oxygen content is so low that burning isn't possible. If a fire is extinguished with carbon dioxide in a small closed room, it should be ventilated immediately. Carbon dioxide isn't poisonous, but lack of oxygen can cause unconsciousness in the fire fighter.

**Pump Tank Extinguisher.** The pump tank is made in two and one-half and five gallon sizes containing plain water or a non-freezing solution. Hard pumping will force a stream 30 to 40 feet. Although difficult to use while being carried, it can be refilled while it is in use.

This extinguisher is suitable for use on Class A fires in ordinary combustibles and Class B fires in flammable liquids. It should not be used for fires in electrical equipment.

**Vaporizing Liquid Extinguisher.** In the past, some plants have used small hand extinguishers that contain carbon tetrachloride. Because carbon tetrachloride can be toxic, this type of extinguisher is not recommended.

## DRY CHEMICAL CARTS

For fires too big to be controlled by hand extinguishers, one or more large dry chemical extinguisher carts are located strategically throughout the plants, usually housed in their own separate enclosure. Their operation is similar in all respects as the hand extinguishers.

One major point to remember in the maintenance of both the hand and cart extinguishers concerns the hoses attached to the bottom of the chamber. It is possible for the dry powder in the extinguisher to become packed solidly enough in the hose to prevent the operation of the unit. For this reason every inspection of the extinguisher should include a hose check. The cart extinguisher should be turned upside down after use and powder removed in the hose with excess nitrogen before it is refilled. *This must be done after each use,* or the hose will pack with powder, making the unit inoperable for use when needed. Figure 56 shows a typical installation.

A typical inspection schedule is shown in Table 2.

## SNUFFING AND SMOTHERING SYSTEMS

At certain points in the plant where there is a greater than normal danger of fire, special means are provided to guard this point. The means most often employed are called snuffing, smothering, or fogging systems. These snuffing systems are frequently installed at the rich oil heater, because open flames are present in the heater.

This system should consist of a network of fogging valves located under the heater so that when the steam of water is turned on the resultant fog will cover the heater area. Also, some means of injecting steam directly into the heater is very good in case of tube failure. This same system may also be used for purging the heater.

This type of system can control and put out fires because it removes the heat present in a fire below the ignition temperature of the fire. When water is used it is discharged thru fog nozzles to produce a very large

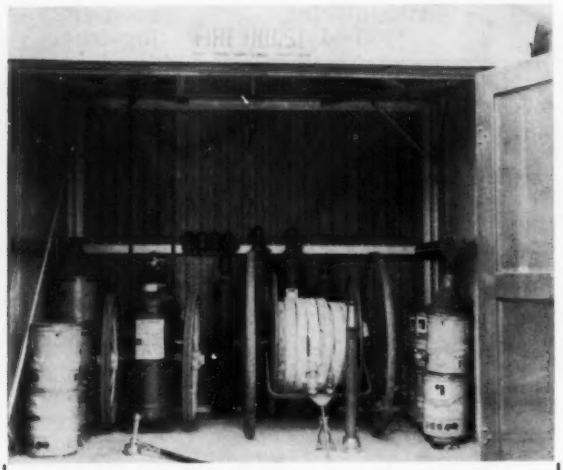


FIGURE 56—This fire house has foam cans, dry chemical cart, gas cylinders, and hose cart.

**TABLE 2—Inspection Schedule**

**Semi-Weekly**

The engine-driven fire pump should be started and run 30 minutes to be sure it is in perfect operation condition. The gasoline tank should be checked and refilled as necessary to be ready for any emergency.

**Monthly**

a. Check hand and cart extinguishers to see that they are servicable.

b. Check Lead and wire seals to be sure the cartridge has not been punctured.

c. Check large extinguisher cylinder pressure gauges. Pressure limits before replacements are necessary may be obtained from the manufacturer.

**Quarterly**

a. Repeat monthly inspection, check hoses and weigh each cartridge.

b. Fill in inspection tag and make out Fire Extinguisher Inspection Report.

number of tiny drops of water. These drops of water are directed toward the hottest part of the fire where the water is turned into steam, thereby taking away the heat from the fire and causing it to go out. When steam is used, the extinguishing method is one of concentration, since steam keeps the air away from the fire until the amount of oxygen present falls below combustion needs.

## BYPASS SYSTEMS

In case of a fire or emergency in a plant that would mean a plant shutdown, some means has to be provided to let this natural gas go around or bypass the plant. This is generally done by installing automatic valves in the lines into and out of the plant. These valves are connected to a separate system of either electrical or gas operated switches located at key spots within a plant.

In the event of a major fire, one of these switches should be closed. This will automatically close off the pipe line gas to and from the plant, and open the bypass line around the plant. In some cases this operation is not automatic and certain valves have to be manually closed and opened.

A bypass around a plant can be compared to a bypass around a motor valve. If the motor valve that controls the feed to a demethanizer tower is not working properly then the whole fractionation process will be upset. To prevent this, the operator will open the bypass around the bad motor valve and control the flow of feed to the demethanizer manually. Similarly, the bypass around the plant not only removes a danger to the plant, but allows the flow of natural gas to continue without any interruption.

## SHUTDOWN SYSTEMS

Shutdown systems are used to eliminate, minimize, or control damage to plant personnel or property only after all other types of preventive action have failed. This is because, generally speaking, when a unit or process is normally in operation and it has to be shut down, then the whole plant or a large portion thereof is affected to the extent it, too, has to be shut down.

Many different parts of a plant have various types of shutdown equipment installed. For instance, examine those found on a compressor and engine. Most installations have, at a minimum, four different types of shutdown protection for a compressor and engine.

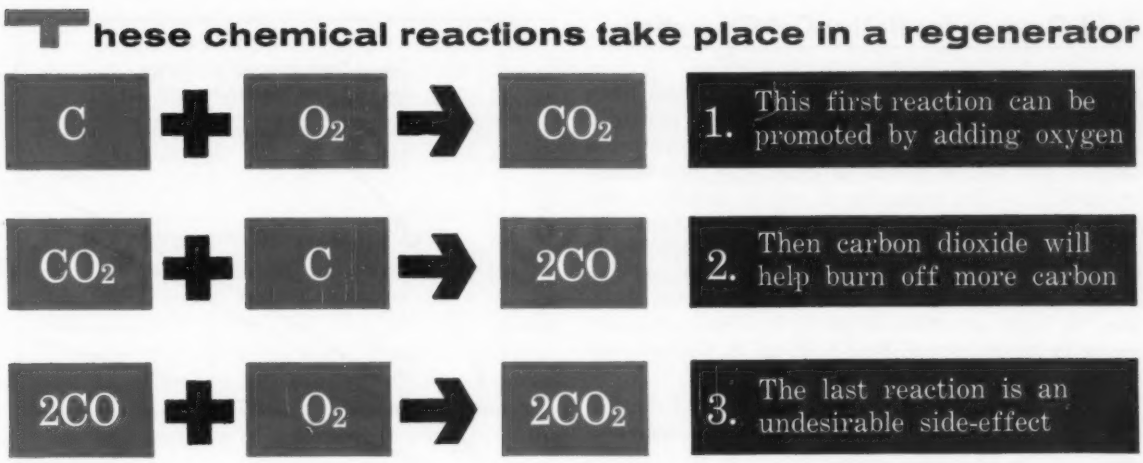
1. **Overspeed Shutdown**—The engine itself is equipped with an automatic overspeed device which shuts the engine down at a predetermined rpm. This is generally done by grounding the ignition system.
2. **Overheat Shutdown**—Again the engine is equipped with an automatic temperature device which operates off the jacket water temperature of the engine and shuts it down at a predetermined temperature by again grounding the ignition.
3. **Low Oil Pressure Shutdown**—Again the engine itself is equipped with an automatic control which operates off the engine oil pressure and shuts down the engine at a predetermined minimum pressure.
4. **High Liquid Level Shutdown**—There is an automatic high level shutdown device installed on each compressor suction scrubber to prevent liquid from being carried into the compressor cylinder. This is necessary because of the fact a liquid is not capable of being compressed to any practicable extent. If the scrubber fills to a certain level, a relay is tripped which shuts down the engine, thus eliminating the possibility of liquid reaching the compressor cylinders.

Other types of equipment which are protected with automatic shutdown devices are oil heaters, boilers, gas lines, pumps, etc. The oil heaters are generally protected by either a low pressure shutdown device, a high temperature device, or a combination of both. Usually the high temperature shutdown device is located so that when the fuel gas temperature of the heater exceeds a certain maximum the fuel gas to the heater is shut off. The low pressure shutdown device is connected to the oil stream. If a tube should rupture (with a corresponding sudden loss in pressure) or the oil pump should fail, then the pressure device will also shut off the fuel gas to the heater.

Boilers are generally equipped with a low water level shutdown device whereby the fuel gas to the boiler is shut off in case the water level drops below a predetermined point. Gas lines are sometimes equipped with motor valves that will automatically shut off the flow if dangerous conditions of pressure, temperature, or flow rate should exist. Some vital pumps are equipped with an automatic device that shuts the pump down if there is no flow through the pump. These are known as "low-flow" switches and are generally installed on electric motor driven pumps.

There are many more types of shutdown devices on the market, but they all work on one of the aforementioned principles—pressure, temperature, level and flow.

**(TO BE CONTINUED)**


These chemical reactions take place in a regenerator
C + O2 → CO2
1. This first reaction can be promoted by adding oxygen
CO2 + C → 2CO
2. Then carbon dioxide will help burn off more carbon
2CO + O2 → 2CO2
3. The last reaction is an undesirable side-effect

# Add Oxygen for Better Cat Operation

**When catalytic cracking operation is limited by regeneration capacity, consider oxygen enrichment to give you better carbon burn-off. Here's how the technique works**

**J. A. Rabo and J. B. Powers**
Linde Company, Division of Union Carbide Corporation, New York City

FLUID CATALYTIC CRACKING units are frequently limited by regenerator coke-burning capacity. When oxygen-enriched air is used, these regenerators can be made to burn more coke and thus give increased thru-puts and over-all economies.

The use of pure oxygen in auxiliary regenerators would offer greatly improved rates of regeneration, low carbon content of the regenerated catalyst, and improved catalyst throughput in standard equipment. Significantly improved catalyst activity and selectivity may be an important feature of the resultant low carbon content of the regenerated catalyst.

**Commercial tests** were conducted during the past year in a co-operative program by Linde Company, Division of Union Carbide Corporation and Cities Service Oil Company at the latters East Chicago, Ind., refinery. These tests, which were made on a 22,500-bpd fluid catalytic cracking unit, verified that oxygen enrichment of regenerator combustion air is a technically sound process.

Oxygen addition rates up to 150,000 cfh were employed, which represents a 4 percent enrichment to 27 weight-percent oxygen concentration. Based on coke-burning capacity, this was equivalent to an increase to 69.5 percent from 60.5 percent conversion, or an increase in throughput of 23 percent at 60.5 percent conversion. In effect, the addition of oxygen increases capacity without the capital expenditure otherwise incurred for a new cracking unit.

## HOW OXYGEN ENRICHMENT WORKS

Catalytic cracking units using silica-alumina catalyst are usually operated at 850° to 950° F. About 2 to 3 weight-percent coke is deposited on the catalyst during the cracking process. This deposit must be removed to maintain catalyst activity. Regeneration is accomplished by continuously transferring a portion of the spent catalyst from the reactor to a catalyst regenerator, where the coke deposit is burned with air at temperatures ranging between 1050° and 1200° F. The pressure normally ranges from 8 psig to 20 psig. The regenerated catalyst, which has about 0.5 weight-percent carbon, is then returned to the reactor.

**The regeneration** of spent catalyst involves three main reactions:

$$C + O_2 \rightleftharpoons CO_2 \quad (1)$$
$$CO_2 + C \rightleftharpoons 2\,CO \quad (2)$$
$$2\,CO + O_2 \rightleftharpoons 2\,CO_2 \quad (3)$$

Reaction (1) represents the net effect of the two oxidation reactions occurring at the solid-gas interface. Carbon monoxide and carbon dioxide are formed si-

multaneously by combustion of the coke in the lower portion of the regenerator bed, but the carbon monoxide is oxidized to carbon dioxide in the presence of excess oxygen. The carbon dioxide produced can then initiate reaction (2). The oxidation of carbon monoxide and carbon dioxide, according to reaction (3), occurs in the upper dilute catalyst phase or above the catalyst bed in the presence of excess oxygen. Reactions (1) and (2) are, therefore, the actual coke burnoff reactions. Reaction (3) only consumes oxygen and, being exothermic, results in an undesirable heat build-up in the regenerator system.

Reactions (1) and (3) are exothermic, and the formation of carbon dioxide is favored at lower regeneration temperatures. Conversely, reaction (2) is endothermic and is favored at elevated temperatures. Therefore, high temperatures decrease the equilibrium $CO_2/CO$ ratio and improve oxygen utilization.

**The factors influencing** the above reactions are the thermodynamic equilibria at the reaction conditions and the relative reaction rates. The equilibrium conversion and reaction rates are dependent on the thermodynamic properties, temperature, pressure, and the concentration of the reactants. The coke-burning process may be analyzed by considering that most of the oxygen is consumed by reaction (1) in the lower portion of the regenerator bed, producing the carbon dioxide required for reaction (2). The resultant carbon monoxide is likely to react with residual oxygen in the upper section of the regenerator (reaction 3). Depending on its magnitude, this latter reaction is termed "controlled" or "uncontrolled" afterburning.

The thermodynamic equilibria for all three reactions must be considered in interpreting the actual composition of the reaction products. Over a temperature range of 1000° to 1300° F, reaction (2) is essentially complete. The same is true of reaction (3). The oxidation of carbon by carbon dioxide (reaction 2) proceeds to a significant extent only at temperatures above 1000° F.

**Reaction rate effects** should also be considered. The combustion of carbon to form carbon dioxide is rapid at 1100° F even without catalytic effects. The rate of reaction (2) is slower and is influenced catalytically. Although reaction (3) is slow below about 1100° F, it is increased considerably by catalytic effects. Cracking catalysts contaminated with iron oxide catalyze the oxidation of carbon monoxide and result in high $CO_2/CO$ ratios in the flue gas.

At regenerator operating temperatures the three reactions have the following relative rates:

First—Reaction (1)
Second—Reaction (3)
Third—Reaction (2)

With sufficient oxygen present, carbon dioxide would be the only product of the carbon burnoff. In the regeneration of catalyst, it is desirable to operate at a low $CO_2/CO$ ratio in the exit gas. This requires the major portion of the oxygen to be consumed in the zone directly above the regeneration gas inlet. The remaining portion of the bed should contain excess carbon in order to provide favorable conditions for reaction (2). A low oxygen concentration in the dilute phase prevents afterburning.

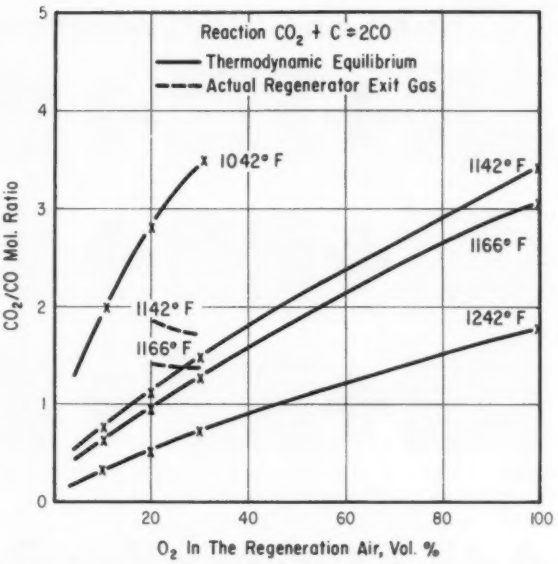



**FIGURE 1—Effect of the $O_2$ concentration on the $CO_2/CO$ ratio in the regeneration air.**

If most of the oxygen is consumed in the lower portion of the regenerator bed in the production of carbon dioxide, the $CO_2/CO$ ratio in the exit gas will be governed by reaction (2). The presence of excess oxygen in the upper portion of the bed will upset the $CO_2/CO$ ratio.

### Effect of Reaction Conditions

Figure 1 shows the effect of various reaction conditions on the $CO_2/CO$ equilibrium ratio. According to this data, the ratio increases with increasing oxygen concentration in the inlet gas, and with increasing total pressure. Since reaction (1) is controlling in the lower portion of the regenerator, an increase in the oxygen concentration of the regeneration air has a similar thermodynamic effect on the increase in the $CO_2$ concentration in the regenerator bed. At increasing temperatures the $CO_2/CO$ equilibrium value drops considerably within the range of the usual regenerator operation.

After the equilibrium value is reached, increasing the oxygen concentration will result in an increase in the $CO_2/CO$ equilibrium ratio. The effect of oxygen enrichment at equilibrium conditions can be balanced then by a slight increase in regenerator temperature to maintain a low $CO_2/CO$ ratio.

Consideration of the effects of pressure on the thermodynamic equilibrium of the reaction (2) shows the $CO_2/CO$ ratio increases with increasing pressure. In the interest of efficient oxygen utilization (i.e., a low $CO_2/CO$ ratio), it is desirable to operate the regenerator at low pressure. High oxygen partial pressures, which are desirable for high burnoff rates, can be achieved at

low total pressure only through oxygen enrichment. If the air is partly replaced by oxygen, the total amount of regeneration gas is less; consequently the total pressure in the system will be lower for the same oxygen throughput. This will result in a decrease in the $CO_2$/CO ratio, and thus an over-all increase in oxygen efficiency will be achieved.

### PROVED BY COMMERCIAL TEST

The commercial-scale test indicated oxygen enrichment improved regenerator efficiency, as well as providing the expected increase in coke-burning capacity. There was evidence of a decrease in the $CO_2$/CO ratio (Figure 1), of greater efficiency of oxygen utilization with increasing oxygen concentration in the regenerator air, and of a lowering of residual coke content on the regenerated catalyst.

Regenerator performance at oxygen enrichments up to 27 percent oxygen content in the regenerator air suggests the $CO_2$/CO ratio is controlled by the reaction rates rather than by equilibria. However, once equilibrium is reached, high oxygen concentration results in an increase in the $CO_2$/CO ratio. As oxygen exerts its principal effect on the $CO_2$/CO ratio through an increase in carbon-oxidation reaction rate, the optimum oxygen concentration is influenced somewhat by regenerator design and operating conditions.

If the oxygen content in the regeneration air is increased to something less than a 30 weight-percent content, the burnoff rate will increase in the initial regeneration zone. Here the rate of burnoff is high because of the high coke and oxygen concentration. Since the oxygen content decreases sharply as the coke is consumed, the effect of the initial oxygen content will be minor within the subsequent zones in the regenerator where both oxygen and the coke content are low. The over-all rate effect can be substantially improved if pure oxygen is used for the burnoff before dilution with the main regeneration air.

**Best results** can be achieved if the pure oxygen is introduced in a small auxiliary regenerator and reacted with partially regenerated catalyst (0.5 coke) from the main regenerator (Figure 2). In this manner the coke content of the catalyst can be reduced to below 0.1 weight-percent in substantially shorter contact time than is encountered in normal regeneration. The flue gas from the auxiliary regenerator, containing a high $CO_2$ content and the unused oxygen, can be used to enrich the main regenerator air and further increase the rate of burnoff in the main regenerator.

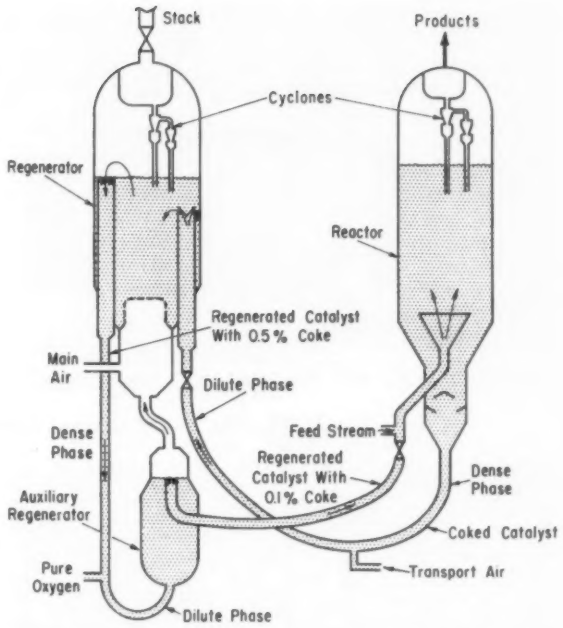



**FIGURE 2—How auxiliary generator can be added for oxygen enrichment.**

Low carbon content of the regenerated catalyst is a unique advantage of using pure oxygen for burnoff. A low carbon content strongly increases the catalytic activity and probably increases the selectivity of the catalyst for gasoline production. This effect cannot be evaluated on the basis of present available data, but it can be considered as a possible technical advantage of oxygen enrichment.

During the cooperative Linde Company—Cities Service Company test, oxygen enrichments up to 27 percent by weight in the regeneration air were investigated, using oxygen additions up to 150-tons-per-day rate. Most of the test data was collected using an oxygen enrichment of 100 tons per day, giving a final oxygen content in the regeneration air of 25.5 weight-percent.

Process control was smooth and uniform over the entire range of enrichment. Coke-burning capacity of the regenerator increased in proportion to the additional oxygen available for combustion. Temperature control and oxygen content in the flue gas did not change appreciably from normal operating conditions encountered with air. Trends toward improvement in oxygen utilization (pounds of oxygen per pound of coke burned) and reduction in residual coke on the regenerated catalyst were indicated when using the higher oxygen concentrations.

This cooperative experiment proved that oxygen enrichment is a sound technique for increasing the catalytic cracker capacity by 10 percent to 20 percent. Considering that fluid catalytic crackers are, in most cases, limited by the regenerator capacity, the oxygen enrichment offers an economical method of increasing the capacity in regenerators limited by permissible gas velocity. ##

## About the Authors

**John B. Powers** is a supervisor, Research Planning, at Linde's Tonawanda Laboratories. He has been with Linde since 1948. Prior to this, he attended Columbia University to obtain a B.S. and M.S. degree in chemical engineering.

**Jule A. Rabo** is a development associate at Linde's Tonawanda Laboratories. Prior to his three years' service with Linde, he was assistant professor of chemistry and associate director of the High Temperature Research Institute of Budapest. He holds an M.S. degree in chemical engineering and a Ph.D. degree in chemistry from the Technical University of Budapest.

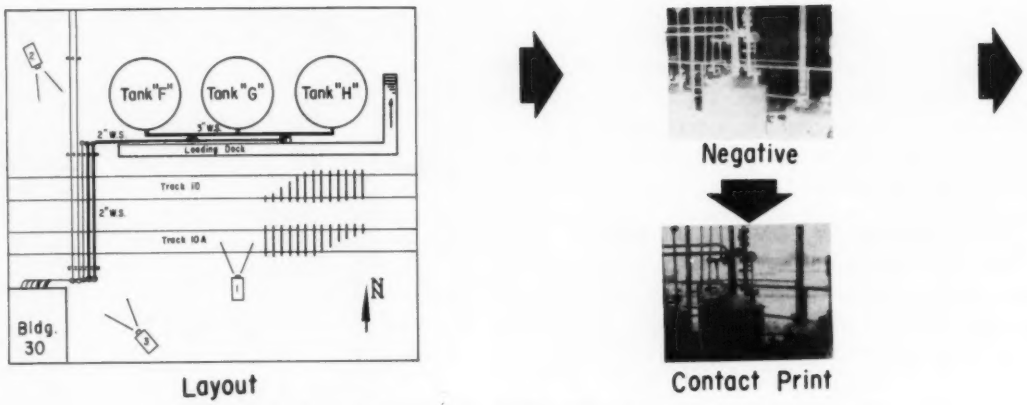



FIGURE 1—Layout shows camera angles. Contact print is optional.

# Cut Your Drafting Costs With

**Use your plant darkroom and a reproduction machine to make photo-prints. A small amount of drafting time completes the drawing for a plant revision**

**W. F. Taffee, Jr. and W. A. Kuhn**
Monsanto Chemical Company, Monsanto, Ill.

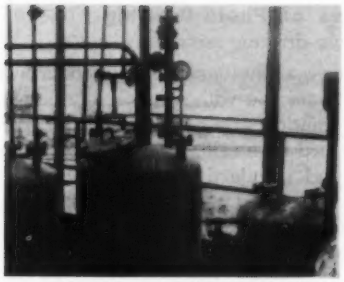
PHOTO-DRAFTING can help cut engineering costs on many of those revision jobs handled in your plant every year. As a bonus, the craftsman can visualize the work to be done much easier than he can by working with conventional prints.

A photo-drawing transparency of an existing installation can be made for a fraction of the drafting costs required to revise old tracings prior to adding the revision. And the transparency can be made for as little as $3.70 which is usually less than the cost of one hour's drafting time.

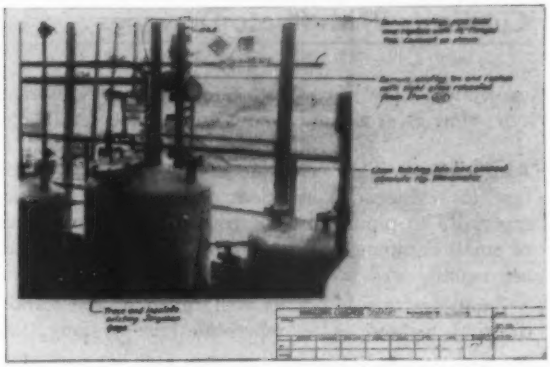
## STEPS IN PHOTO-DRAFTING

1. The first step in the use of photo-drafting techniques is to prepare a layout drawing of the area covered. This should provide sufficient detail to indicate the relative position of equipment, pipe line routes and other general information. A typical layout drawing is shown on Figure 1. This drawing shows the areas photographed, the direction from which the picture was taken, identity numbers for each picture and compass orientation. Building numbers, tank identification and other conventional information are included. New piping is shown as heavy lines and existing piping as light lines. This drawing has proved to be of exceptional value in tying together the individual photo-drawings to form an information package, which presents a complete picture of the desired installation in a form which can be easily used by engineers, draftsmen, pipe fitters and mechanics.

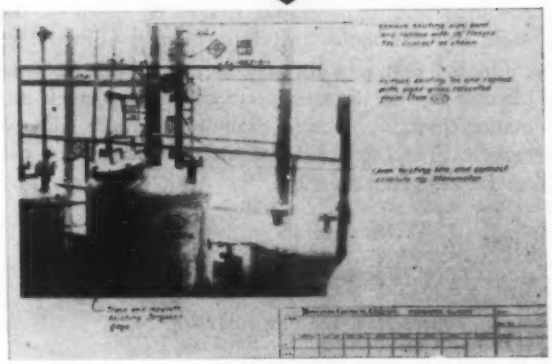
2. After the layout has been prepared, the next step is to obtain the transparency and to assemble it with



Positive Enlargement



Enlargement Mounted On Pre-Printed Stock



Diazo Print

**Final print is proof that photo-drafting gives the craftsman a better view of what's to be done than does a conventional line drawing.**

# Photo-Drawings

the drawing stock. Producing the transparency is simplicity itself. To do this an enlargement is made using normal techniques except that a translucent sensitized film base is used in place of ordinary enlarging paper. Assembly is accomplished by mounting the transparency (or several transparencies) on a larger sheet of drafting cloth or other suitable drafting material using drafting mending tape. The transparency is mounted emulsion side up on the side of the drawing material which is normally used for pencil or ink work. A preprinted drawing stock having a space for title block, revisions, approvals, etc., is preferred. Figure 1 shows the general steps involved in preparing a photo-drawing.

**3.** After mounting the transparency, the next step is to letter in the identity number for the particular picture as indicated on the layout drawings, add a compass orientation arrow, an any other pertinent information which will assist in identifying the particular picture involved. After this is done, a diazo print is made and forwarded to the engineer in charge of the job.

**4.** The engineer then takes the diazo print and sketches in, free-hand, the proposed installation in its final location showing all of the elements necessary to provide sufficient information for construction purposes. Dimensions may or may not be shown. The marked print is then returned to the draftsman for completion of the finished photo-drawing. If there are areas on the transparency which need to be removed to permit the drawing in of new equipment, valves, and piping, or to permit the addition of notes, these areas may be removed from the transparency by wet erasing. This merely involves dampening the tip of a mechanical eraser and proceeding to remove the emulsion down to the photographic film base. After the photographic details have been removed in the desired areas, the material which has been indicated on the photo-print is added by standard drafting techniques.

A soft pencil or India ink is necessary for good reproduction. The soft pencil is preferable, even though it tends to smudge slightly, because it's much simpler to make corrections.

Changes or corrections at this stage may be made, without destroying photographic detail, by manually erasing the pencil lines from the transparency and redrawing.

The pictures are usually taken obliquely so that isometric projection is approximated. It is relatively easy to line up with straight lines in the picture and to draw your own lines in parallel even though the true isometric projection is not used. Some installations will lend themselves to camera views which are similar to orthographic

projection. However, the "oblique view" or isometric type view gives a more readily interpreted result.

**Application.** The technique of photo-drafting applies best to revisions or additions to existing installations, especially to piping and electrical installations. Placing of small equipment and revisions to existing structures are equally well covered by photo-drafting techniques.

Photo-drafting is not as well suited as the standard drafting techniques to representations of long, fairly straight runs of pipe. In this case, sketches can usually be substituted for formal drawings. If, however, the long runs of pipe include multiple changes of direction, "christmas trees," or other auxiliaries associated with the pipe line, photographs should be taken of these areas and the photo-drafting techniques utilized.

On the first jobs the tendency is to take too many pictures and in an attempt to convey too much information through the use of many photographs. However, experience will soon indicate what your particular needs are for any given situation.

## About the Authors

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Taffee

**William A. Kuhn** is the process superintendent for the Plant Technical Services Department, Monsanto Chemical Company, W. G. Kummrich Plant, Monsanto, Ill. His duties include the administration and supervision of a group of engineers performing all phases of design work connected with new products, expansion of old products and process improvement projects primarily in the fields of hydrogenations and chlorinations of organic heavy chemicals. Kuhn received a B.S. degree in chemical engineering from Purdue University in 1947 and has done graduate work at Washington University in St. Louis. All of his professional experience has been with Monsanto having worked with the production of pharmaceuticals and plasticizers, as a design engineer, and in application research (organic products) before assuming his present position.

Kuhn

**Advantages of Photo-Drafting.** The main advantages of photo-drafting are these:

- If you have a photographic darkroom available, this method provides you with a quick, simple means of preparing information and getting it on record. The technique described here utilizes only standard photographic darkroom and standard drafting methods. No special equipment is required and no special handling problems are involved.
- The photo-drawing is usually less expensive than preparing the same information by conventional methods. Compared on the basis of detail shown, photo-drafting is decidedly less expensive. This method of conveying information provides excellent detail (in many instances more than is actually required), and is easily interpreted by anyone, no matter how unfamiliar he is with blue print reading.
- With a picture to look at, instead of a collection of lines, the individual reviewing a print can much more readily visualize what the finished installation is going to look like. On this basis, the comments received from others who review the drawings before installation are more meaningful and undesirable portions of installations are caught on the drawing board rather than having to correct them in the field after installation.

**Costs.** If 10 or more enlargements are required they can be produced for a maximum of $3.70 each.

This cost includes enlargements to 11 x 14-inch size—the cost of all materials—and the largest item—the photographer's time-most of which is spent in consulting with the project engineer and taking the pictures.

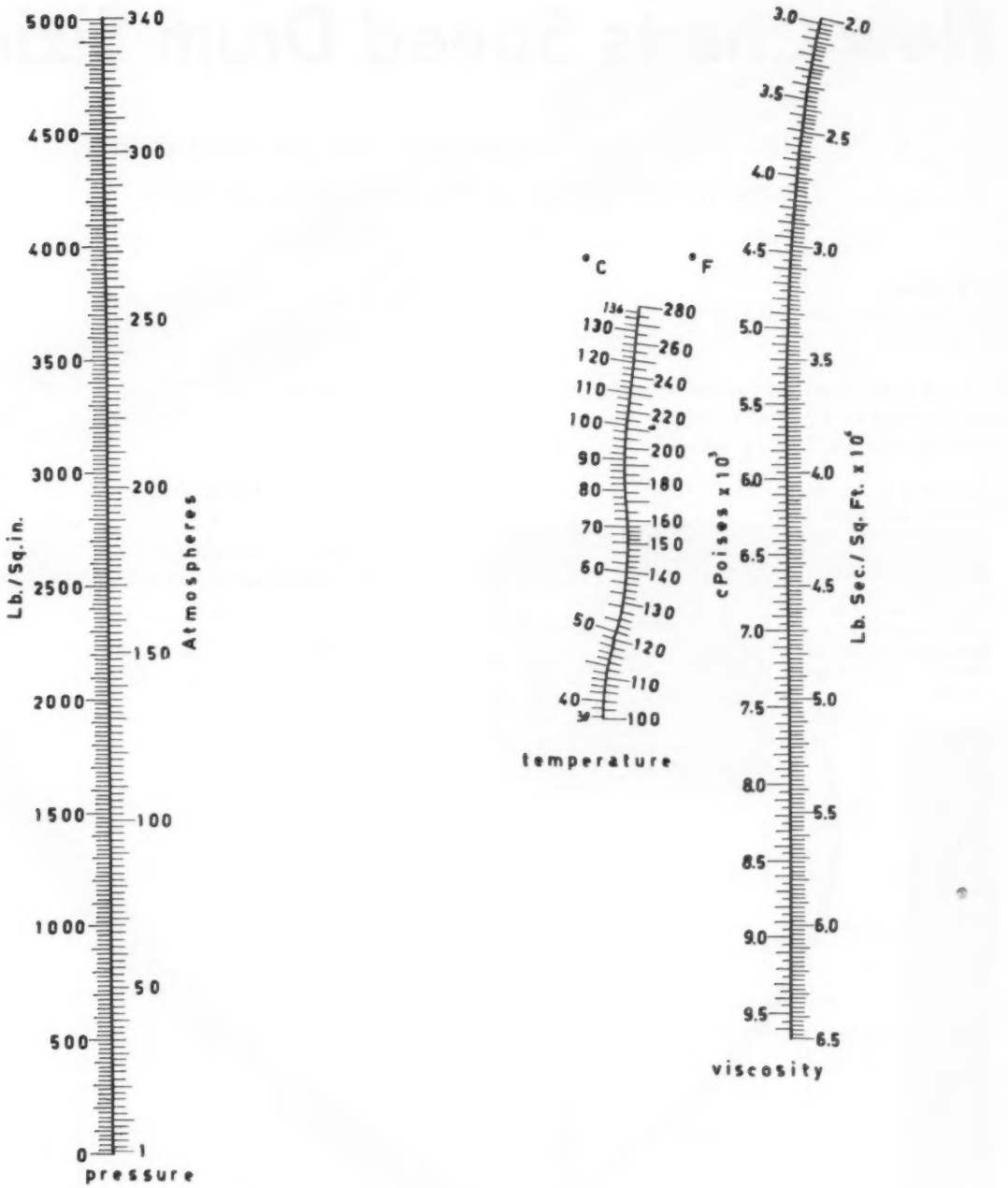
The total cost for 10 different pictures breaks down this way:

| | | |
|---|---|---|
| Cost of materials | | $ 9.00 |
| Cost of photographer's time | | $28.00 |
| estimated at 5.00/hour | | $37.00 |
| | or | 3.70 each |

This, incidentally, is usually less than the cost of one hour of draftsman time (it is only a fraction of the time frequently spent in copying and revising old tracings, prior to starting the actual drawing revisions).

Although a formal cost or efficiency comparison has not been run between the time required for craftsmen to install a job using conventional drafting techniques and one using photo-drafting techniques, it is believed that the job using photo-drafting techniques goes in somewhat less time. The reason being that the craftsman does not have to translate the image he sees on a drawing to what the physical installation actually looks like. He can look at the photographs and the layout drawing and by knowing where this particular photograph was taken he can orient himself in the field much more readily. The craftsman can see essential details without additional mental effort in visualization: exactly where a pipe line is supposed to run, exactly where a valve is located, which way the handle is to be turned, how a pump is to be piped up, etc. All these things are much more readily grasped by the craftsman who is using the photo-drawing as opposed to one using conventional drawings.

Originally presented to the AIChE St. Louis Symposium, March 15, 1960. # #




# Find Viscosity of Liquid *n*-Pentane

**A.M.P. Tans**
Staatsmijnen in Limburg, Geleen, The Netherlands

RECENT MEASUREMENT by Reamer[1] of the viscosity of *n*-pentane in the liquid phase as a function of temperature and pressure is the basis for the accompanying nomograph.

The use of the nomograph is as follows: Any line connecting a point on the pressure scale with one on the temperature scale intersects the viscosity scale in a corresponding point, e.g., at 2,000 psi and 220° F liquid *n*-pentane has a viscosity of 3.34 $10^{-6}$ lb.sec./sq. ft.

LITERATURE CITED

[1] Reamer, H. H., Cokelet, G., and Sage, B. H., Anal. Chem. 31, 1422 (1959) No. 8.

# New Charts Speed Drum Sizing

**This graphical method for sizing dry and reflux drums is a real timesaver when making preliminary estimates**

**G. D. Kerns**
The Vickers Petroleum Company
Wichita, Kan.

A QUICK, error-free method of sizing process vessels is needed by the process engineer in preparing preliminary estimates. While a method which is error-free may never be found, the charts presented here can be used to approximate the sizes of dry drums and reflux drums at the rate of five minutes per item with a minimum of error. Consistency in design basis is automatic and the range of valid applications is very broad, covering most refinery and petrochemical processes.

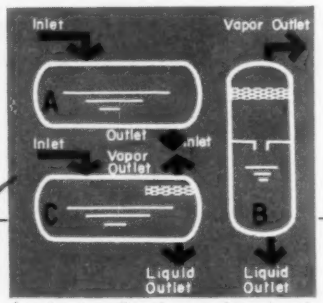



**FIGURE 1—Use these positions and piping arrangements for classifying drums into—(a) Horizontal for totally condensed streams; (b) Vertical for mist removal from vapors; (c) Horizontal for separation of vapor-liquid mixtures.**

## THE METHOD:

Graphical calculations save time and minimize errors. However, the real trick lies in advance consideration of the simplifying assumptions which can be made without serious sacrifice of accuracy.

**1.** All drums shall have the same relative dimensions, length equal to three diameters. This assumes that

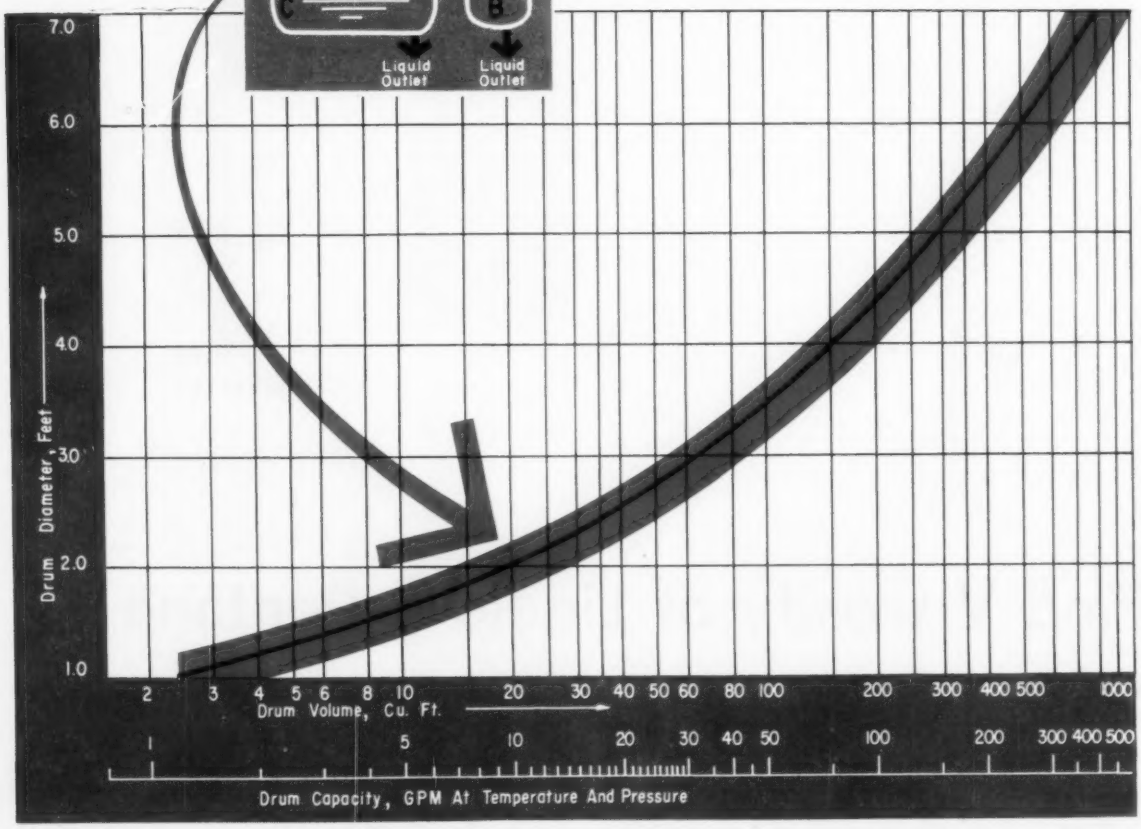



**FIGURE 2—Reflux drum sizes for handling totally condensed liquids are based on two conventions—(1) L/D = 3, drum diameter to be rounded off to the nearest diameter and height added, when needed, up to L/D = 4; (2) Holding time of 7½ minutes with drum half full.**

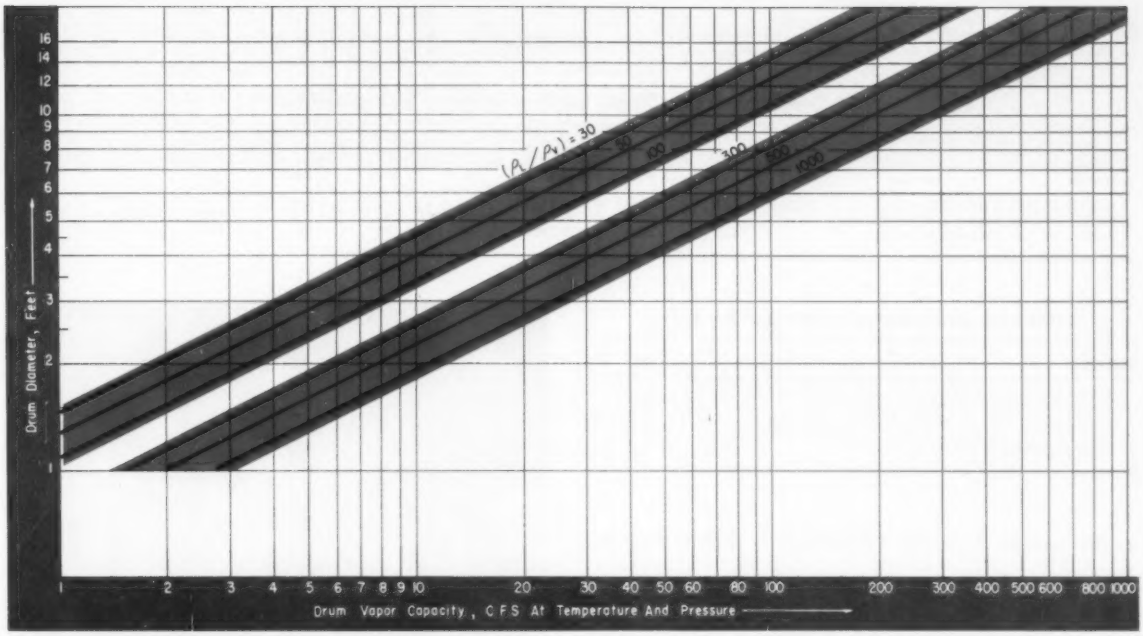



**FIGURE 3—Flash drums and gas separator sizes are obtained from this chart as follows—Vertical Dry Drum: (1) Obtained diameter from Figure 3; (2) Obtain height from L/D = 2 to 4, overall height to be not less than 4'-0" tangent to tangent. Horizontal Drums: (1) Obtain diameter from Figure 3; (2) Obtain diameter from Figure 2 and use the larger of the two diameters; (3) Obtain length from L/D = 3; (4) Drum is assumed to run half full of liquid.**

the L/D ratio of 3, commonly considered an optimum shape for storage drums, will also result in a dry drum with about the right residence time.

**2.** The density of the vapor is negligible, relative to the density of the liquid. This is a common assumption in vapor-liquid calculations at moderate pressures. A typical example might be:

$$\frac{\rho_L - \rho_V}{\rho_L} = \frac{33.0 - 1.2}{33.0} = \frac{31.8}{33.0} = 0.96$$

Thus, this assumption is characteristically good to 5 percent or better.

**3.** The hold-time for liquids shall be 7½ minutes with the drum running half full or 15 minutes based on total capacity. This is a common practice for reflux drums handling a single liquid phase. Where a second liquid such as steam condensate is to be disengaged from the main process stream, this design basis should be doubled by multiplying both the drum diameter and length by $\sqrt[3]{2}$ or 1.260.

**4.** The volume of the dished heads is negligible for purposes of a preliminary estimate. This can be shown easily for 2:1 elliptical heads which have a volume equivalent to D/6 feet of additional drum length.

$$\frac{\text{Volume per Head}}{\text{Cylinder Volume}} = \frac{(D/6)A}{(3D)A} = \frac{1}{18}$$

Thus, the volume of one head is about 5 percent of the cylinder volume at L/D = 3. This is consistent with the accuracy of most preliminary flow sheets and much better than the accuracy with which the required hold-time is known.

## THE CHARTS

Use of the chart based on these assumptions is simple. The process flow sheet or supplementary data sheet usually provide the following: Liquid thruput at operating temperature, gpm, vapor volume at operating temperature and pressure, cfs, operating density of the liquid, lb./gal., and operating density of the vapor, lb./cu. ft. Use of a tabular calculation such as Table 1 is recommended to prepare the data and record results.

**Drums Handling Totally Condensed Liquids.** The horizontal arrangement of Figure 1a is assumed. Using the hot gpm, a drum diameter is read from Figure 2

**TABLE 1—Calculation Sheet for Preliminary Sizing of Drums**

| Item Number | Service | $\rho_L$ lb./gal. | $\rho_L$ lb./cu. ft. | $\rho_V$ lb./cu. ft. | $\frac{\rho_L}{\rho_V}$ | $V_{CFS}$ @ T and P | $Q_{GPM}$ @ T and P | $f_s$ | D | L |
|---|---|---|---|---|---|---|---|---|---|---|
| F-101 | DIB Reflux Drum | 4.16 | 31.2 | ..... | .... | .. | 126 | .... | 4'-9" | 14'-3" |
| F-204 | Compressor J-16 Feed Drum | 4.50 | 33.7 | 0.186 | 181 | 41 | 2 | 0.62 | 3'-6" | 10'-6" |
| F-303 | Cold Propane Separator | 4.37 | 32.8 | 0.166 | 198 | 23 | 52 | 1.00 | 4'-3" | 12'-9" |

**TABLE 2—Capacity Factors for Different Dry Drums**

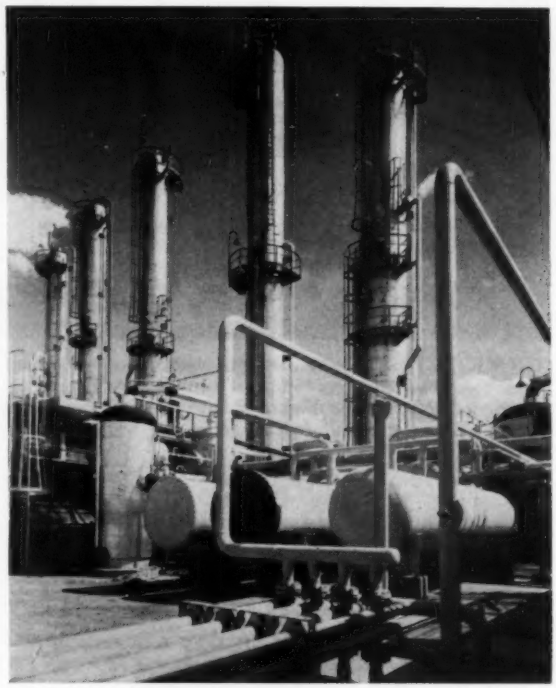
| SERVICE | $f_s$ |
|---|---|
| Vertical Drum, No Mesh | 1.00 |
| Vertical Drum, Conventional Mesh[1] | 0.65 |
| Vertical Drum High Capacity Mesh[1] | 0.62 |
| Design Diameter = $f_s$ x Chart Diameter. | |

to the nearest 3 inches. The length is three times this diameter.

When disengaging a second, minor liquid phase, such as water, the diameter read from Figure 2 should be increased 26 percent before rounding off and calculating length.

**Drums with Small Entrainment Loads.** The vertical arrangement of Figure 1b is assumed. Figure 3 gives the diameter required for drums with no wire mesh. It is based on the well known "bubble-tower" equation of: $V_{max.} = 0.227 \sqrt{\frac{\rho_L - \rho_V}{\rho_V}}$ with a design velocity of 0.50 V max.

Using the appropriate combination of V and $\rho_L/\rho_V$, obtain a diameter from Figure 3 and multiply it by a mesh capacity factor from Table 2. The length is three times this diameter for large drums. Length should be increased to four times this diameter for smaller drums and never less than 4' 0" between tangents.



Quickly size process drums using data in this article.

**Vapor-Liquid Separators with Appreciable Liquid Loads.** The horizontal arrangement of Figure 1c shall be used and a mesh blanket shall be installed at the outlet with an area equal to 40 percent of the cross-sectional area of the drum. A tentative diameter is taken from Figure 2 based on liquid load and another from Figure 3 based on vapor load. The larger of these two diameters is used, rounded off to the nearest 3 inches. The length is three times this diameter. Separation of a liquid third phase requires an increase of 26 percent in dimensions obtained from Figure 2.

Undoubtedly, many users will find other modifications of these charts which will make them more useful for their special needs. It is the author's hope that the approach to preliminary process design applied here will stimulate others to publish the "quickie" charts in their design workbooks.

## About the Author

**Gordon D. Kerns** is technical director of Vickers Petroleum Company's Potwin, Kansas, refinery. He received a B.S. degree in chemical engineering from the University of Minnesota in 1949 and an M.S. in chemical engineering from the University of Delaware in 1954. He has worked in technical service with Sun Oil Company at Marcus Hook, Pa., and in research with Standard Oil Company (Indiana). Before joining Vickers, he was in manufacturing coordination with Amoco Chemicals Company.

Kerns

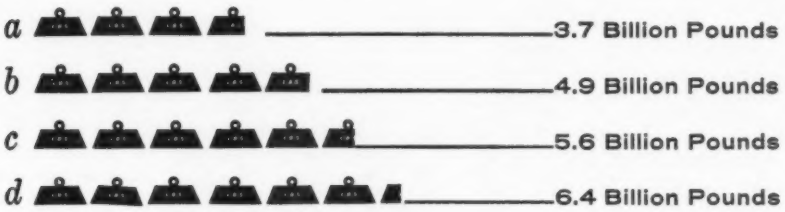
LITERATURE CITED

[1] Bulletin No. 111, Schuyler Manufacturing Corporation, North Arlington, N. J.

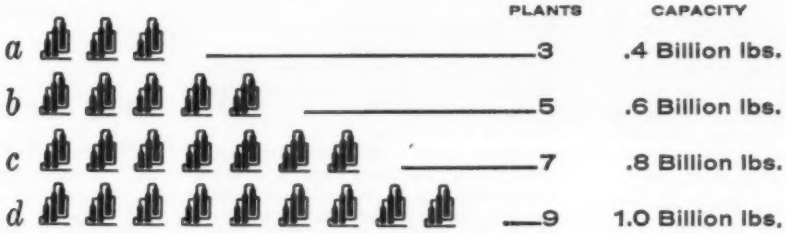
# what's your best estimate?

*...a quiz for Petrochemical Executives who want to keep posted*

**QUESTION 1.** In 1959, 28 plants in the United States were producing ethylene—the hydrocarbon intermediate which is way ahead of all others both in quantity produced and in versatility. What was the estimated total U. S. capacity for this valuable chemical in 1959?




**QUESTION 2.** How many of the U. S. ethylene plants were designed, engineered and constructed by the Lummus Company?

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**ANSWERS: 1.** *The answer is (c)—5.6 billion pounds, according to* Chemical Week's *Report on Ethylene, May 9, 1959.*

**2.** *Again the answer is (c). In the last 10 years Lummus has 7 Ethylene plants to its credit in the U. S. alone with a combined capacity of .8 billion lbs. Lummus' world-wide total is 13, with a combined capacity of over a billion pounds per year. For ethylene projects, or any type of process plant, call on Lummus' 50 years of experience in design, engineering and construction.*

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## Employee Discipline

"Employee Discipline" points out that governing employes is the real drama of labor relations. Here are no small issues. For management, the stakes are nothing less than the right to control the operation in an orderly, efficient way. For the employe, the stakes are his job, his security, his seniority rights, and his status in the group. Differences are so pronounced that fully 30 percent of all grievances that go to arbitration are based on disciplinary decisions of management. This book discusses these differences. It is an examination of discipline procedures, and of the common law of the shop that has developed out of thousands of grievances and arbitrations over the issue of "just cause" for discharge.

The plan of the book is to take each area of employe discipline and see what standards can reasonably be applied for the protection of both management and employe rights. These areas include insubordination, absenteeism, fights and altercations, dishonesty and disloyalty, gambling, incompetency, damage to machines and materials, strikes and strike misconduct, and union activity. The author has developed guidelines useful to employers, employes, and unions in determining the "rights" of the discipline process. In each area he surveys for the reader the management arguments for what it considers to be right in disciplinary standards. And in counter-argument, he presents the union rationale on what is and what is not proper employe behavior in an industrial enterprise.

(Stessin, Lawrence, *Employee Discipline*, The Bureau of National Affairs, Inc., 1231 24th St. N. W., Washington 25, D. C., 315 pages, $7.85)

## Radiation and Polymers

"Atomic Radiation and Polymers" reviews the many scientific papers and short articles that have been published and covers the changes produced in materials by atomic radiation from reactors, or by electron radiation from high-voltage sources. All aspects of the subject, from the commercial production of new types of polymeric material to fundamental studies impinging directly on reactor design, radio-biology, radiation chemistry and solid-state physics are discussed. The first book published in this field, this volume begins with the basic principles and develops up to the most advanced work carried out on this subject.

(Charlesby, A., *Atomic Radiation and Polymers*, Permagon Press, 556 pages, $17.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

## LPG Specs, Test Methods

"Liquefied Petroleum Gas Specifications and Test Methods," latest revisions (October 1959) are available. The book, NGAA Publication 2140-59, brings up-to-date the specifications, tests, and sampling techniques proposed by the NGAA in connection with LPG. Topics include: Definitions and Specifications of LPG, Vapor Pressure Test, Specific Gravity Test (both pycnometer and hydrometer methods), Specific Gravity Reduction to 60° F for LPG, Corrosion Test (Copper Strip Method), Volatile Sulfur Test (Lamp Method), Dryness Test for Commercial Propane (both cobalt-bromide and dew point methods), Residue Test for Commercial Propane (mercury freeze method), Weathering Test for Butane and Butane-Propane Mixtures, Weathering Test for Commercial Propane, and the Sampling Method.

(NGAA, *Liquefied Petroleum Gas Specifications and Test Methods, October 1959 Revisions (Publication 2140-59)* Natural Gasoline Association of America, 421 Kennedy Bldg., Tulsa 3, Okla., 35 pages, $1.)

## API Supplements

Volume III, Chemical Wastes, Manual on Disposal of Refinery Wastes (23-page supplement)" has been published by API. Also just published is "Chapter VIII, Direct-Fired Boilers and Auxiliary Equipment, Guide for Inspection of Refinery Equipment. The 35-page chapter contains a description of types, reasons for inspection and causes of deterioration. It suggests frequency of inspection, safety precautions and preparatory work, methods of inspection and repair, and records and reports.

(API, *Volume III, Chemical Wastes, Manual on Disposal of Refinery Wastes*, (23-page supplement), $1: *Chapter VIII, Direct-Fired Boilers and Auxiliary Equipment, Guide for Inspection of Refinery Equipment*, 35 pages, $2.)


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## AIChE Pump Manual

"AIChE Pump Manual" was prepared to answer some of the needs manifested by a comprehensive questionnaire issued to more than 100 manufacturers and users of pumps throughout the United States. It describes the more generally used types of pumps, and serves as a guide to which type may be best for a given service. A glossary of terms is provided, and standard data sheets for both inquiry and record are presented, as is a brief guide to the solution of pump corrosion problems. Also included is the complete text of the official "AIChE Performance Testing Procedure for Centrifugal Pumps," and a section is provided for the insertion of the "Mechanical Pump Standards" which will be issued by the A.S.A. Of special interest is a section on inquiry and record sheets. This section gives sample forms filled in for inquiry, quotation and record.

(AIChE, *AIChE Pump Manual*, American Institute of Chemical Engineers, Publications Department, 25 West 45th St., New York 36, N. Y., 79 pages, $10 for members, $20 for others.)

## Pump Application Manual

"Centrifugal Pump Application Manual," a handbook "to acquaint users of pumps with the general forms and types of centrifugal pumping equipment and to aid them in understanding pump operation and intelligent pump selection," has been published. Starting basically with the principles of centrifugal pump operation, the manual treats the many factors involved in handling the broad range of liquids under widely differing conditions imposed by industry's requirements today.

Discussed and illustrated are such considerations as viscosity effects; cavitation and suction lift; temperature rise in pumps, packing and seals; installation and trouble-shooting. More than 50 illustrations, charts and tables are included in addition to reprints of the Centrifugal Pump and Data Sections of the Standards of the Hydraulic Institute as reference.

(*Centrifugal Pump Application Manual*, Buffalo Pump Division, Buffalo Forge Co., Department 43, 490 Broadway, Buffalo, N. Y., 227 pages, $5.)

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# HOW POWER AFFECTS HUMAN BEHAVIOR

**In some situations, the supervisor must exercise absolute control over a subordinate—at times the reverse is true. Most often, however, each should give and take a little to achieve the proper balance within the power spectrum. This is a true test of leadership**

**Robert R. Blake and Jane S. Mouton**
The University of Texas, Austin

POWER IS A CENTRAL FACTOR in human relationships. Nothing could be more significant for comprehending the human factors which influence the operation of a plant or office than understanding the consequences of different uses of power.

On the one hand, the two person situation characterized by the phrase supervisor-subordinate is surrounded by implicit assumptions regarding power. Work direction, supervision, discipline and performance-review all involve the use of power. On the other extreme, as soon as the concept of an organization is dealt with, systems of coordination and control such as chain of command, span of control, delegation of authority and so on immediately come to mind. All refer to how social power is distributed to get work done.

Through applied group dynamics experiments within the setting of a management development laboratory, we have gathered some interesting information on how people react to the extremes between hard, tight control and the loose rein approach. This article describes some of the experiments, sample results and generalizations regarding power use in connection with supervision.

**Power Styles in Supervision.** Supervision is leadership, and one effective approach to studying leadership is to examine the leadership act—the act of leading. How does a person who is in a position to lead do so? Does he throw his weight around? Does he retain tight control over the subordinate, does he share his power so that they can move jointly, or does he use a loose rein approach? What are the effects on both supervisor and subordinate of various possible approaches?

**The Power Spectrum.** One way of actually measuring leadership is by evaluating the amount of weight an individual exerts on a decision made by himself and a subordinate. This is called the power spectrum. Take, for example, the system where two people work together. At the left side within the collaboration area shown in Figure 1 is the situation where the person in the position of leadership actually controls all of the weight on the decision. He receives a weight of 1. On the other hand, the subordinate receives a rating of 0 because he contributes nothing to the outcome. This is known as a 1/0 system of collaboration.

At the opposite extreme is the situation where the person officially designated as the supervisor exerts no weight whatsoever, and as a result the subordinate makes the decision. This is known as the 0/1 condition. The subordinate controls the entire weight exercised in determining the decision.

As shown in Figure 1, the distribution of weight between a supervisor and a subordinate can be any ratio between 1/0 and 0/1. It can be .8/.2, or .7/.3, or

**The Power Spectrum**

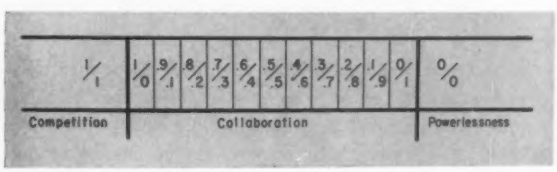


**FIGURE 1—One way of measuring leadership**

.5/.5, or .4/.6, and so on. Although the example here involves the power relationship between only two people, it can as well be a single leader and several other people who form the work system. A department head may give no power to his subordinates as a group, or he may share it with them in different ratios, depending on the decision under consideration, and so on.

**Competition.** The spectrum can be extended so that on the extreme left there is a competitive relation where each person seeks to achieve or retain the total decision-making weight. This situation then is one of contest, with the two competing, each seeking to influence the other, so that as one succeeds, the other fails.

In a capitalistic economic system, this approach to the distribution of economic power is appropriate between organizations, unless an organization gets so strong that it has 1 unit of strength and all others have 0. Then a monopoly situation exists, and that's generally recognized as unhealthy. As long as there are a number of companies, each trying to grow stronger, but with no one getting too much, then the conditions for sound competition are present. The 1/1 competition between companies is healthy as long as they follow legal and ethical rules of competition.

Labor-management relations are intended to form a collaborative system, approaching .5/.5. However, too frequently collaboration breaks down and turns into competition with many of the features of a 1/1 type relationship. The 1/1 labor-management situation is present when the groups themselves are unable to resolve disputes and when it becomes necessary to appeal to arbitration or to resort to strike.

In the case of arbitration both management and labor reduce their power to 0 and raise the power of the arbiter to 1 in order to break the deadlock and to re-establish a working basis. The same is true when it becomes necessary to invoke the Taft-Hartley law to provide a cooling off period in order to turn away from competition and re-establish collaboration.

**Powerlessness.** Over on the other end, at the right extreme of Figure 1, and labelled "powerlessness," the scale can be extended to a point where there is no weight available to be distributed between individuals or groups. This approaches an 0/0 situation. There are some conspicuous and highly instructive examples of this kind of situation. The Texas City disaster is typical. In that situation, there was no adequately prepared plan to cover the size of the emergency and, for a critical period, individuals were unable to exercise sufficient influence on one another to achieve the coordinated effort necessary for restoring order. The result was that people walked into one another, or away from one another, or parallel, but they were not connected enough to influence each other. They were powerless.

Critical periods, mergers between companies, or between units within a company tend toward 0/0 situation. No one can answer anyone else's questions, old rules no longer apply and people are powerless to influence one another or to get decisions which permit necessary actions. Particularly noteworthy is the reduction in morale that may come about during a merger period when power relations have not yet been re-established.

**Demonstrating Relationships.** In an applied group dynamics laboratory, participants experience the three power styles, 1/0, .5/.5, and 0/1, in the setting of a supervisor-subordinate relationship. Each supervisor conducts problem-solving conferences with three different subordinates. The task is to rank three sets of 10 different items in their order of importance for improving management, one set being ranked with each of the three subordinates.

Here is one of the three sets, concerning characteristics useful for selecting a middle manager. Differences of opinion between a supervisor and his subordinate provide the basis for interaction.

**ITEM**

1. Ability to grasp structure of organization quickly and use it effectively
2. Able to give clear-cut instructions
3. Able to change own conclusions where proven to be wrong
4. Able to delegate effectively
5. Keeps all parties concerned fully informed on progress and final actions
6. Capable of making fast decisions under time and pressure
7. Able to resist shaping an opinion before all facts are in
8. Goes about decision-making by developing a range of alternatives before coming to a final verdict
9. Capable of seeing appropriate relations among a variety of items
10. Able to grasp instructions and act appropriately in terms of them.

One time during the three interactions the supervisor behaves in a 1/0 manner, retaining the power and influencing the outcome as much as possible. In a second pairing he participates in a .5/.5 collaborative manner, rubbing ideas with the subordinate until they achieve a mutually acceptable ranking of the items. On a third occasion he relinquishes all power to his subordinate in a 0/1 manner, avoiding influencing the subordinate's

## Relationship Between Power Distribution and Satisfaction with Participation

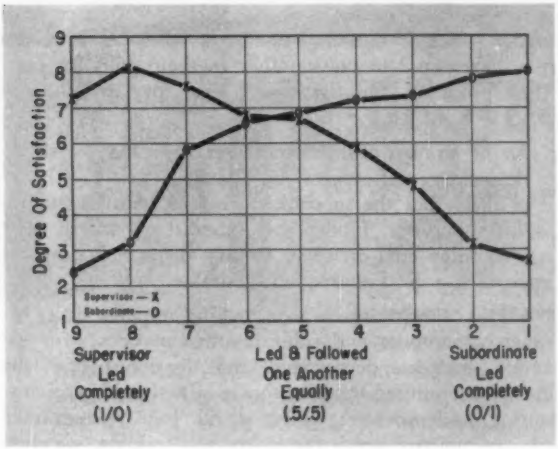


**FIGURE 2—The greater the personal power the greater the satisfaction; but highest overall balance of satisfaction between supervisors and subordinates is when power distribution approaches .5/.5.**

opinions in any way. Subordinates are unaware that the supervisors change their behavior in this manner.

After each interaction, both the supervisor and the subordinate describe their reactions. The leadership scale ranges from a rating of 9 for "The supervisor led completely," (the condition of 1/0 in the power spectrum) to 1 for "The subordinate led completely" (the condition of 0/1). The cohesion scale, "How much satisfaction did you derive from your participation," ranges from 9, "Completely satisfying experience," to 1, "Completely dissatisfying experience."

Another scale, measures relations between feelings of responsibility and the way power is distributed. It ranges from 9, "Felt completely responsible for the activity," to 1, "Felt a total lack of responsibility."

The reactions of hundreds of managers to different power ratios are summarized in Figures 2 and 3. One shows relationships between power distribution and satisfaction. The other relates the power distribution to feelings of responsibility. Let's look at each a little closer.

**Power and Satisfaction.** The subordinate is dissatisfied when the supervisor leads completely or almost completely. But when he, the subordinate, gains even a small feeling of shared power, his reactions shift from dissatisfaction to moderately satisfying. At the 0/1 end, where he has all the power, his satisfaction reaches its peak and he finds the experience "almost completely satisfying." These trends are shown in Figure 2.

The same holds for the supervisor except that it takes a greater amount of power to tip the balance on the side of satisfaction for him. As you see, the highest individual satisfaction is found where one member controls the balance of power, but this satisfaction is at the expense of dissatisfaction by the other. In other words, wielding power is a highly satisfying experience, but the cost of wielding power is to destroy the satisfaction of the other person.

The positions in the middle of the power distribution—especially .6/.4 and .5/.5—give the most equal amount of satisfaction for both supervisor and subordinate. The important implication here is that if the 1/0 model of authority-obedience is inappropriately used, it leads, inevitably, to trouble. This means that in normal work situations, you should exercise your power, not in terms of your needs to wield it, but in terms of the needs of the situation. The 1/0 is acceptable if the situation is an emergency. It isn't if people feel they should have a voice in decisions which is being denied them. Something in the neighborhood of .6/.4 or .5/.5 produces the best results, if it is realistic within the framework of an operating situation.

**Power and Responsibility.** Figure 3 shows the relationship between power and feelings of responsibility. The general finding is that feelings of responsibility by both supervisor and subordinate peak at the .5/.5 position on the power spectrum. When the balance of power is in favor of either member of the pair, responsibility on the part of *both decreases,* but the decrease is more rapid for the member who *loses* power. The greater the imbalance, the lower the feelings of responsibility by the person whose power is reduced. Only when power is shared, or when it is close to a joint relationship, do both accept full, or close to full responsibility.

These findings have clear implications for understanding the chronic complaint of many supervisors that "subordinates just aren't responsible—they don't accept the responsibility given them." The suggestion here is that when you see people acting this way, re-examine the power distribution between yourself and your subordinates.

When subordinates feel they have a measure of power or influence, then they willingly accept responsibility.

## Relationship Between Power Distribution and Feelings of Responsibility

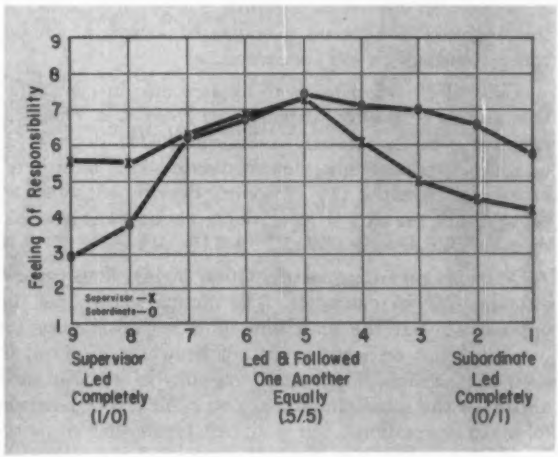


**FIGURE 3—Best balance between power distribution and sense of responsibility is around .5/.5.**

The situation changes from a 1/0 or authority-obedience, to something closer to joint-determination and mutual responsibility with common goals.

**Refinery Examples of Power Ratios.** In the actual work situation, the strategy of how power is used can be analyzed according to the power spectrum, whether the situation involves two people, a small group, two groups or the organization as a whole. The following summaries represent concerted opinions regarding power use by people with years and years of refinery experience behind them.

**The 1/0 Situation.** In a number of cases, leadership is an acceptable 1/0 proposition. Emergency plans and operations must be of a 1/0 character particularly under conditions of danger such as a unit fire where there must be immediate decisions in order to control disaster. Another 1/0 situation would be where a foreman sees and stops a welder from burning in an area where there may be a heavy concentration of oil vapors.

Another general situation where 1/0 is appropriate is when there is inadequate information or lack of competence on the part of a subordinate. Along these same general lines, a relationship between a supervisor and an untrained man in matters of pure instruction on work direction often is 1/0.

**The 0/1 Situation.** In many situations, however, an 0/1 type of relationship may prevail—especially as people achieve greater technological skill and as industry moves toward multi-craft supervision. Then the supervisor may no longer be able to direct a more skilled subordinate. The supervisor is rendered powerless relative to the skill of his own subordinate. For example a mechanical supervisor with a background as a pipefitter who has been made responsible for an electrical job must rely heavily on the craftsman for job method decisions.

Frequently immediate action is required and the supervisor is incapable of acting so the subordinate must make the decisions. For example, in the event of an emergency shutdown in pumping gas or oil to tankage, the operator decides on a course of action which becomes binding on all concerned.

The 0/1 situation tends to happen also in companies that practice rotation extensively. Here is a chemical engineer who is rotated to Personnel. He doesn't get bogged down in details; he coordinates! He "interprets" broad policy while the Personnel department operates pretty much on an 0/1 level, doing about what it would do even if he weren't there.

Decisions regarding participation in benefit programs also are 0/1 in character. The company provides the opportunity but the man himself is responsible for his own decisions on whether or not he wants to enroll in such a program. Suggestion programs of various sorts also have the same character. You can't direct a person to make suggestions, but you can create the situation in which he takes the personal responsibility for offering his thoughts on new techniques, processes, procedures, etc.

**The .5/.5 Situation.** A .5/.5 approach, or something close to it, can best be used when there is time for interaction and discussion. By and large in companies where people have been employed 15 to 20 years, it is highly probable that any two layers of supervision are relatively equal to one another in their skills for handling problems. On the ability level they are close to .5/.5.

As the number of layers increases, there may be ability or knowledge differences, but between any two layers it is likely that the subordinate is just about as skillful as his supervisor. Under these conditions, where there is a common goal or where feelings of participation are important, a .5/.5 approach is desirable.

Mutual sharing of decision-making responsibilities between supervisors and subordinates can occur, for example, between department and division heads who meet to determine the best course of action in receiving, storing, and processing of gas or oil. Jointly-determined job assignments, needs for on-the-job training, vacation rules, and schedules also fall in this category.

The .5/.5 is also significant in relations among groups. An example where this approach can be used is in scheduling turnarounds which has an overriding effect on the operation of several departments. For instance, the Mechanical department is involved from the view of equalizing mechanical workload by staggering turnarounds to fit in with manpower availability; supply and distribution are concerned from the standpoint of efficiently carrying out their functions associated with the turnaround. Scheduling a turnaround under .5/.5 conditions is essential as the cooperation and understanding of all parties are necessary to insure success.

Union-management relations many times have a .5/.5 character. True collective bargaining is an example.

**In Conclusion.** You might summarize the application of the various positions on the power spectrum by saying that as you move away from emergencies into activities where individuals have great personal skills for handling the situation you move from 1/0 toward 0/1. Between these extremes many situations exist where a .5/.5 approach is optimal. However, in addition to the reasons already given such as a high degree of satisfaction and high feelings of responsibility associated with it, a .5/.5 situation is a learning situation par excellence. It means that as people make decisions they are more or less automatically teaching one another. Thus, a plant or office moves toward success in close parallel with the extent to which it teaches people the skills of collaboration when it's desirable—and self-reliance when it's possible.

**In Applied Group Dynamics: Part 4, which will appear next month, you will read about:**

1. **How the power spectrum applies to employe evaluation.**
2. **How to arouse a greater sense of team play.**
3. **Developing a sense of responsibility in subordinates.**

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(Temp. Range: Atmospheric to 2400°F.)
This low or moderate temperature type is used where service temperatures do not exceed 2400°F. Used for many heating boilers and furnaces, door linings, furnace floors, ash pits, flues, ducts, etc.

**Hi-Cast No. 28**
(Temp. Range: 1800°F.-2800°F.)
For high-temperature service. Suitable for temperatures up to 2800°F.

**Hi-Cast No. 30**
(Temp. Range: 2000°F.-3000°F.)
An especially refractory type, equal to the best grade of fire clay brick, to use at very high temperatures.

**Super Hi-Cast** (P.C.E. 34)
High-temperature castable refractory for use at elevated temperatures beyond the limits of ordinary castable refractories. Ideal for burner cones, door linings, walls, roofs, arches and other applications where mix may be poured into forms.

**CELLO-CAST**—Combination refractory and insulating material, widely adaptable in replacing insulating brick and tile. Cello-Cast has low thermal conductivity and low heat storage. Apply in heating furnaces, boilers, and industrial furnaces not subjected to slag attack or mechanical wear.

**Cello-Cast No. 20**
Temp. Range Atmospheric to 2000°F.

**Cello-Cast No. 24**
Temp. Range Atmospheric to 2400°F.

**HI-CAST AR**—A very high strength, abrasion resistant refractory. Useable for service temperatures not exceeding 2750°F.

*Serving Industry with Fine Refractories Since 1876*

**Denver Fire Clay Company**
3033 Blake Street—Denver 17, Colorado
DENVER • SALT LAKE CITY • NEW YORK

**THE DENVER FIRE CLAY COMPANY**
3033 Blake Street — Denver 17, Colorado

Please send further information on DFC Castable Refractories. DFO-6

*Name:*.....

*Company:*.....

*Address:*.....

*City and State:*.....



For more data on advertised products, use Readers' Service Cards, last page.

*As Management Sees It...*

# Six Ways To Promote Safety

**Stimulating interest in your plant's safety program is a never-ending job. So here are six ways you can help keep that safety interest alive**

**H. E. Carroll**

ACCIDENTS cost money! But in addition to the out-of-pocket expense for medical treatment and equipment repairs, there are many other hidden costs—lost time, higher insurance premiums, training replacements, lower morale, and the executive time spent in investigation.

Safety programs provide an answer. If interest of the employes is kept at a high level, safety programs can go a long way in reducing the accident rate in your plant. Here are six ways to spark your safety program:

**1. Safety Jury.** Employes will feel they are part of the safety program when they have something to do. The safety jury is one way to keep everyone safety conscious and to handle safety problems in a fair and just manner.

This jury is selected from employes by management or by the employes. They serve for a month, six months or a year depending on the plan. Whenever there is an accident, the safety jury listens to the evidence in the case and makes a decision—carelessness or need for safer equipment.

Another function of the safety jury is to pass on safety equipment purchases. Also, it helps establish safety rules for the plant and sets up procedures for handling accident cases or unsafe practices.

Some executives feel it is best to have one or more members of the management team on the safety jury. Others feel that it accomplishes more when the employes select and participate on the jury themselves.

**2. Daily Safety Report.** Paper work does not make safe work. But, a daily safety report does have value in keeping the accident rate at a low level. Mentioning safety once a week or once a month doesn't build a strong impression. But, when there is a daily or a twice a day reminder of safety, the message is driven home to employes and to supervisors.

You may find that the daily safety report will give your safety program a new lift. One plan is to have the report completed at the end of each shift. It reports any accidents (however minor) and lists any unsafe conditions and makes any safety suggestions that come up.

Another idea is to have a two-part report. The first part is completed after a safety inspection at the start of the shift. The second is the results of the shift's activity in safe practices.

In addition to keeping your employes and supervisors more safety conscious, the daily safety report brings forth some warnings of unsafe conditions and valuable suggestions for your safety program.

**3. Safety Ads.** You may find this a valuable idea to spark the safety program. It not only reaches present employes, but prospective employes and the general public. It reminds your employes of safety and announces to everyone that you have a safe place to work.

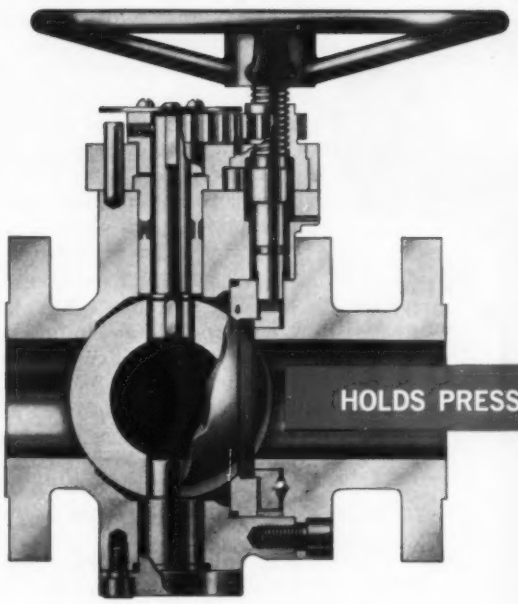
Briefly, this plan takes small space in your local newspaper each day. One-column by one-inch is enough space to tell your safety story as the ad tells how many days you have worked without an accident. Naturally, the copy needs to be changed each day. You can usually make a deal with the newspaper to change the number each day unless notified that you have had an accident.

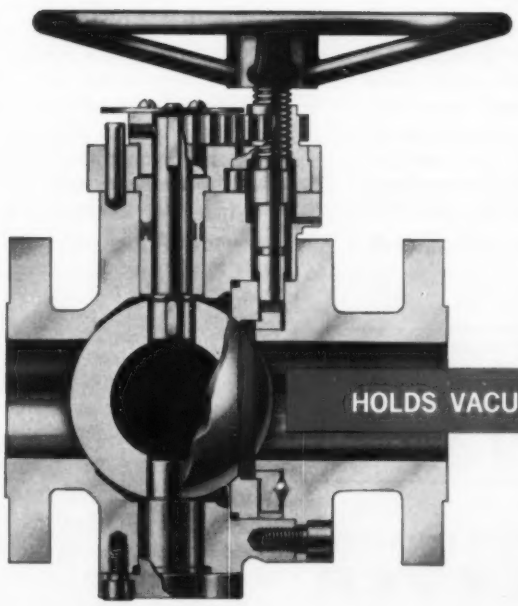
**4. Home Safety.** Encouraging home safety may seem like a left-handed approach to safety. However, it does help accomplish the main purpose of any safety program—keeping employes on the job.

You can encourage home safety by providing various types of booklets and pamphlets. These are either mailed to the employes at home or distributed at the plant to take home. This gives the worker's family a feeling that you are interested in their welfare and since you are so concerned about home safety, they realize that the plant must be a safe place to work.

The National Safety Council has booklets and other material that can provide plenty of fuel for the fire of

# Exclusive Controlled Compressible Port Seal provides fast, positive shutoff in any service...




# HYDRIL BALL Type "K" PLUG VALVES

Controlled sealing . . . a new concept in valve design . . . is the secret of Hydril's tight, bubble-proof shutoff. Hydril Ball-Plug Valves always seal positively against pressure from either direction—or against vacuum—because the fully confined packing ring is mechanically compressed between plug and seat when the valve is closed. This tightly compressed gasket type seal easily bridges clearances between parts as well as surface imperfections. Result: seal efficiency is unimpaired by prolonged hard usage, by rust or sediment.

Design of Hydril Type "K" Ball Plug Valves assures minimum maintenance costs. Non-lubricated, they employ no sealing lubricants. There's no sliding friction between plug and body to produce wear and abrasion.

The spherical plug is mounted on accurately positioned bearings, maintaining a minimal controlled clearance between plug and body. This contributes to easy, free-turning operation as well as to long service life.

●

Hydril valves are available in a wide range of sizes and ratings. Worm-gear and motor-operated models can be supplied. Get the full story on Hydril Valves from your nearby representative . . . or write Hydril Company for free Catalog No. V-60.

## HYDRIL COMPANY

714 West Olympic Boulevard, Los Angeles 15, Calif.

**Factories at: Los Angeles;** Houston, Texas; Rochester, Pa.
**Sales Offices: California:** Bakersfield, Los Angeles, Ventura • **Louisiana:** Harvey, New Iberia, Shreveport **Oklahoma:** Oklahoma City, Tulsa • **Texas:** Corpus Christi, Dallas, Houston, Midland, Odessa • **Wyoming:** Casper **New York:** New York • **Canada:** Calgary, Edmonton



For more data on advertised products, use Readers' Service Cards, last page.

# WORK HORSE... RACE HORSE

## Gardner-Denver piston and rotary air hoists

Only Gardner-Denver offers lightweight overhead air hoists for *both* the "work horse" and "race horse" jobs. Axial-piston hoists provide rugged, dependable operation with the control demanded for precise spotting. That's why hundreds of industrial plants rely on this Gardner-Denver hoist. New rotary air hoists are designed for use where the combination of speed and ruggedness is of primary importance—up to 90 fpm in 500-lb. capacity.

**Popular models available from 150-4000 lb. Sparkproof construction and pendent control available.**

| PISTON HOISTS | | | | ROTARY HOISTS | | | |
|---|---|---|---|---|---|---|---|
| MODEL | CAPACITY | SPEED | WEIGHT | MODEL | CAPACITY | SPEED | WEIGHT |
| 86-1V10 | 1000 | 19 | 28 | 86R-5 | 500 | 90 | 27 |
| 86-2V20 | 2000 | 19 | 78 | 86R-10 | 1000 | 40 | 27 |
| 86-2V40 | 4000 | 10 | 100 | 86R-20 | 2000 | 20 | 30 |

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

**GARDNER - DENVER**

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario


home safety. And, in most cases you will find this organization more than willing to help you organize a program to encourage home safety.

**5. Safety Awards.** Recognition is one of the strongest motivating powers for anything. Accident elimination can be improved when there is some form of recognition or award for safe workers. One of the most obvious methods is to give safety cups or pins indicating the number of years the employe has gone without an accident. These awards are relatively inexpensive and the cost is very small when compared with the cost of accidents or higher insurance premiums.

Another plan is to post the photo of each employe on the bulletin board as he passes a certain landmark in safe service. For instance, when an employe has worked a year without an accident, his photo is posted on a bulletin board for a week.

When this same employe passes the second year mark, his photo (or a new one) is again posted in the Safety Hall of Fame. A variation of this photo recognition idea is to keep the photo on display as long as the employe continues to observe safe practices. If your organization is too big for a central bulletin board, each department can have its own.

**6. Safety Publicity.** Another way to keep everyone conscious of safety is to give your safety program local publicity. This idea can be incorporated with some of the other ideas or used separately. For instance, you can give the story to your local newspaper each time you distribute some home safety information. This will cause interest to increase at all levels for the news in the home safety program.

When your safety jury is selected, the news of this can be given publicity in your local newspaper—names and addresses of your employes serving on the safety jury make news. Or, a feature story about the activities of your safety jury would make interesting reading to local people.

Naturally, every safety award deserves publicity. It is news for the community and added recognition for the employe who has the safety record. Anything and everything you do to promote safety will make good local publicity—and give your safety program an added lift. ##



For more data on advertised products, use Readers' Service Cards, last page.

## PLENTY OF WATER for Springfield-66 MILLION GPD Max.

Springfield, Ohio has a completely new, automatic water supply system by Layne. It guarantees 66 million gallons per day for their present and future needs—a job complete by Layne—and a completely satisfied customer. Field Tests exceeded the guaranteed pump efficiencies by 1% to 2% on all units. Consulting Engineers: Black and Veatch, Kansas City Missouri. Water Supply Contractors: The Layne Ohio Company, Columbus, Ohio. Do you need complete water service? Get it from Layne. Write for Bulletin 100.

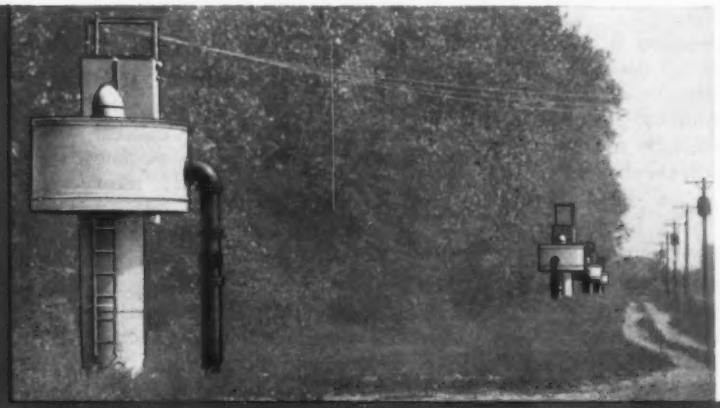
**Specifications**

**RAW WATER**—10 Layne Gravel Wall Wells with Layne 18-8 Stainless Steel shutter screen and 10 Layne deep well pumps. 2800 GPM — 65 ft. TDH, 75 hp—440 Volts— 1750 RPM, located in two banks pumping to the filter beds. Pumps were installed 15 feet above ground level for flood protection.

**FILTERED WATER**—Six Layne high service pumps boosting filtered water into distribution system. Five are 12 MGD-285 ft. TDH, 700 hp—4160 volts—1185 RPM. Two are variable speed units. The sixth Layne Pump is a 6 MGD-285 ft. TDH, 400 hp—4160 volts—1185 RPM. All pumps operate through the central control panel.

City of Springfield, Ohio

LAYNE OFFERS COMPLETE WATER SERVICE: Initial Surveys • explorations • recommendations • site selection foundation and soil-sampling • well drilling • well casing and screen • pump design, manufacture and installation construction of water systems • maintenance and service • chemical treatment of water wells • water treatment—all backed by Layne Research. *Layne services do not replace, but coordinate with the services of consulting, plant and city engineers.*



Layne SINCE 1882 — WORLD'S LARGEST WATER DEVELOPERS

**LAYNE & BOWLER, INC., MEMPHIS**

GENERAL OFFICES AND FACTORY, MEMPHIS 8, TENN.

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

Sales Representatives in Major Cities

*As Management Sees It...*

# How To Develop First-Line Supervisors

**You can have strong, reliable first-line engineering supervisors in your plant through careful selection, orientation and development. Here's how to go about it**

**Howard L. Harrison**
University of Wisconsin, Madison

ENGINEERING DOLLARS can be saved by strong, responsible first-line (lowest-level) engineering supervisors. They save money by providing the most effective means for directing engineering personnel and for conserving economic resources. These supervisors also free higher-level engineering management for the more demanding task of operating an effective engineering department.

If we want strong, responsible first-line supervision we must, in general:

**1.** Select for promotion men who show evidence of strength and responsibility.

**2.** Properly orient these men to the requirements of the job.

**3.** Develop these men to build strength and responsibility. But let's study these in a little more detail.

## WHO—SELECTION

Never promote a man if his only qualification is that he is the best technical man in the group. This point is mentioned first because, in my opinion, one common stumbling block in considering an engineer for promotion is to place too much emphasis on technical ability and not enough on administrative ability. This practice probably stems from the days when the best workman was always thought to be the best candidate for foreman. The result of such a promotion was all too frequently an exchange of a top workman for a poor foreman. This is not to say that technical ability is unimportant. We must remember, however, that part of a first-line supervisor's job is administrative and so a candidate's potential administrative ability must be considered.

"Authorities" list many personal characteristics necessary for success as a supervisor. A man must be friendly, cooperative, sincere, firm, decisive, analytical, creative, resourceful, sensible, thorough, to mention only a few. He must also show good judgment, think objectively, be able to organize, stand pressure, and make money. Many others could be added.

The implication is that all we need to do is to list the qualifications and then judge the candidates for promotion point by point. Such a procedure would be tedious if not altogether impractical.

An evaluation of four personal qualifications will, in my opinion, suffice for making an intelligent selection. These factors are related to the engineering job currently being performed and yet are strongly indicative of a man's ability to handle the job of a supervisor, that job being to get results through others. A suitable candidate for promotion should possess the following qualifications.

**1. Proven Ability To Get Things Done.** A likely candidate is one who is able to handle a job completely without neglecting important details.

*Yardstick:* Does he complete his assignments without leaving loose ends?

An engineer may have the ability to complete assignments but may tend to handle all of the details personally. This inclination is not desirable for a supervisor whose future depends on accomplishment through others.

*Yardstick:* Does he use the service facilities provided or do everything himself?

**2. Performance Oriented.** It is not enough to accomplish things; the right things must be done. A suitable candidate for supervisor must know the economic facts of life. He must realize that engineering is justified only by its contribution to the profit dollar and that the job of an engineering department is to obtain acceptable (not perfect) engineering solutions with the minimum expenditure of time and money.

where trouble-free performance is a matter of pride...

**DOW CHEMICAL COMPANY, TEXAS DIVISION, FREEPORT, TEXAS**

**SCOVILL**®

# Heat exchanger tube

One of the largest of The Dow Chemical Company's manufacturing installations is the Texas Division, where, in complex and brilliantly-painted plants hundreds of different components are processed and re-shaped to produce more than 40 fundamental chemical products.

Chemical process condensers such as this at The Dow Plant, Freeport, Texas, are vital links in the production chain and are tubed with Cupro-Nickel, 30% Heat Exchanger Tubes.

Combining excellent corrosion-resistant properties with very favorable mechanical properties, Scovill Tubes of this alloy make an important contribution to the trouble-free operation of these key units under very exacting service conditions.

Let Scovill Technical Service . . . most experienced in the field . . . help you establish the best heat exchanger tube specifications for equally trouble-free service in your own heat transfer equipment.

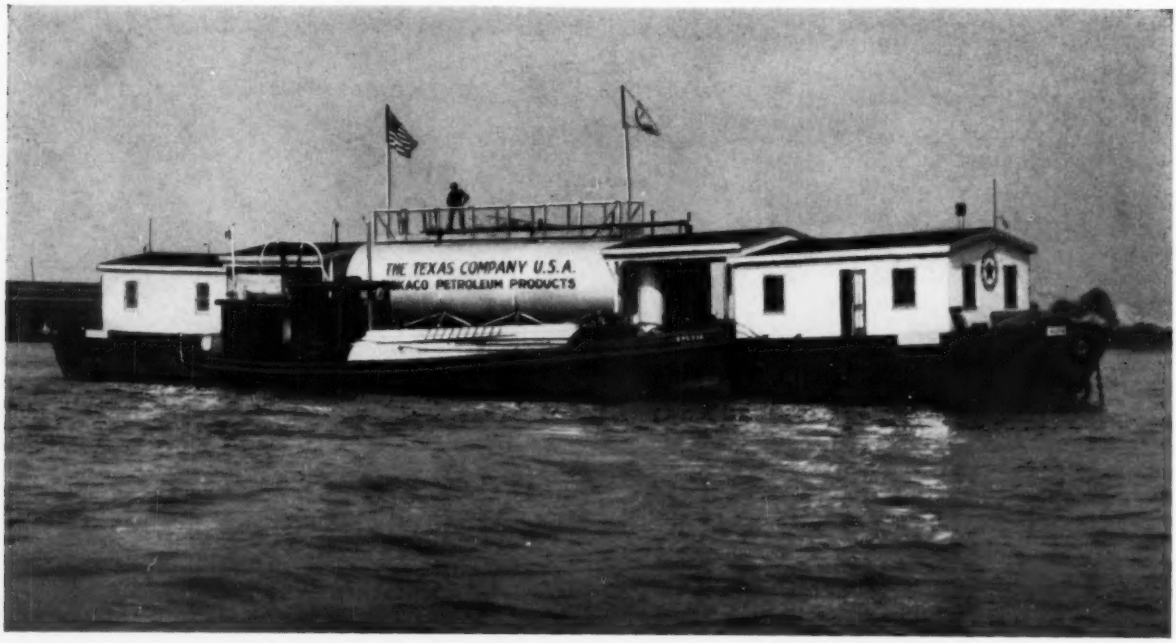
MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

**HEAT EXCHANGER TUBE** for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . . Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel, 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

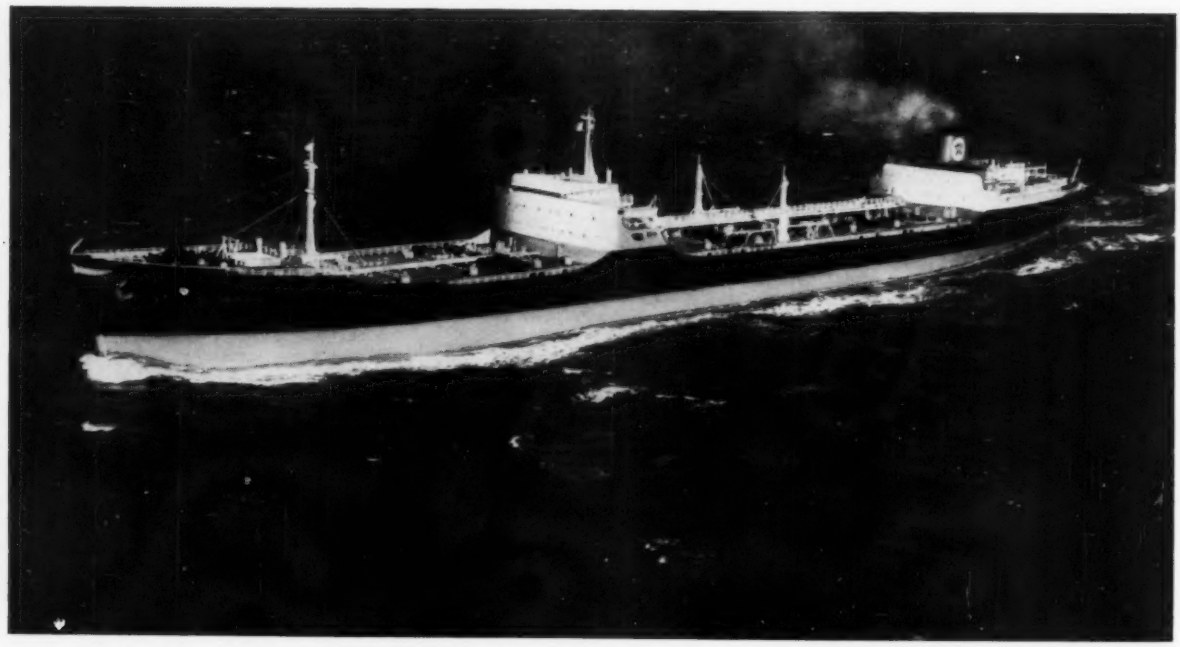
**SCOVILL MANUFACTURING COMPANY, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone PLaza 4-1171.**

95C58R

# From coastal to global operations




YESTERDAY—Shortly after its founding in 1902, Texaco had only one, small, wooden barge—transporting crude oil slowly along the Gulf Coast and up the Mississippi. Its capacity was 170,000 gallons.



TODAY—Texaco's giant steel tankers, like the Trinidad, ply the sea lanes of the free world, carrying up to 13-million gallons. This fleet forms part of a vast transportation network that helps keep the economy of the free world in balance. Continued Texaco growth, national and global, makes this possible.

TEXACO



For more data on advertised products, use Readers' Service Cards, last page.

*Yardstick:* Does he accomplish the right things or does he engineer for engineering's sake?

**3. Strong Sense Of Responsibility.** An engineer, to be seriously considered for promotion, must evidence the personal strength and determination necessary to complete his assignments despite obstacles.

*Yardstick:* Does he meet his commitments?

**4. Ability to Deal With People.** The emphasis here is on effectiveness, not on sociability. A likely candidate is one who, while under pressure to perform, can obtain the cooperation of others without offending. In other words, he must have some finesse, in addition to a will to accomplish.

*Yardstick:* How often does someone complain about his behavior?

These four qualifications obviously include the many personal characteristics previously listed. However, putting the qualifications on a performance basis provides a more feasible method for selecting supervisors.

## WHAT—JOB REQUIREMENTS

What are the job requirements for the new supervisor? We should, from the very beginning, establish areas of responsibility and then discuss them with the man. This approach is sound from our viewpoint in that it assures us that the new supervisor is aware of his responsibilities so that he can take appropriate action. Also, it is only fair that he know the areas for which he is accountable.

**Job Description.** The best way to establish job requirements is to prepare a job description. It should include a general statement of responsibility and a list of general duty areas. (See Figure 1 for a sample job description.) Too much detail should be avoided because it tends to stifle initiative and detracts from the feeling of over-all responsibility which we are seeking to build.

We should be specific in requirements but not in the methods by which objectives are to be met. Remember that our goal is a strong, responsible supervisor. Therefore we should provide the new supervisor with the opportunity of fulfilling his responsibilities in his own way. Besides, he may devise better methods than ours.

The sample job description (Figure 1) includes certain items which some readers may question. For example, should an inexperienced supervisor be responsible for salary administration? My answer is yes, to the extent indicated by the job description. Of course, the new supervisor's recommendations require approval before any action is taken;

DESIGN SUPERVISOR

Statement of Responsibility: The supervision and overall direction of a group of engineers responsible for the design of _____.

Duty Areas: The following list of duties should be considered as including only a minimum of those necessary to fulfill responsibilities.

I. Work direction--schedule, assign, and follow-up on work assigned to group.

II. Personnel activity--

A. Train, develop, etc., personnel to assure top efficiency, good morale, etc.

B.* Interview, hire, transfer, fire, etc., personnel as circumstances warrant.

III. Administration--

A.* Salary--take appropriate action

B. Budgetary

1. Handle wisely the economic resources available to the group.

2. Prepare budgets--operating expenses and capital equipment.

*Recommendations require approval before action is taken.

**FIGURE 1—A good job description is a general statement of responsibility and duties. Too much detail will tend to stifle initiative and detract from the feeling of over-all responsibility.**

this procedure eliminates the hazards of inexperience. Also, an additional benefit is derived in that the man has the opportunity of wrestling with salary administration problems and, can, by so doing, sharpen his judgment.

The job description is not only a convenient means for establishing areas of responsibility but can be used to build a feeling of over-all responsibility on the part of the new supervisor.

### HOW—DEVELOPMENT

How the new supervisor is developed is of extreme importance if we are going to attain our goal—a strong, responsible supervisor. Development is a complex matter but here are several basic suggestions that will certainly help:

**1. Start With a Salary Increase.** We have promoted a capable engineer and are asking him to assume greater responsibility. A salary increase is in order to show our faith in the man and to evidence the fact that we are serious about asking that he assume over-all responsibility for a group of engineers.

This approach is directly opposite that of the "show me and I'll pay you" philosophy. This philosophy is unsound to my way of thinking. Its use demonstrates a lack of faith in the man and implies that, no matter what the level of performance is, the man will always be underpaid. Neither implication is desirable if we wish to build strength and responsibility.

The amount of the salary increase should be at least equal to that of any previous merit increase, preferably more. It is obviously poor policy to give a small increase and at the same time tell the new supervisor that we believe him capable of, and fully expect him to perform at, a much higher level of responsibility.

Some question may arise as to whether a supervisor should be paid more than any engineer he directs. My attitude is that, once he proves himself to be a truly capable supervisor, he should be. Some exceptions are possible in the case of well-recognized, highly-specialized engineers. This attitude stems from the belief that a truely capable supervisor is more rare and can contribute more to an effective engineering department than a capable engineer.

**2. Be Available.** A new supervisor is beset with many problems, although we expect him to learn how to solve these problems, we must offer our support. Exercise care, however, not to make his decisions or do his job. The idea is to serve as an advisor rather than a source of ready-made decisions.

A convenient way to teach the man to solve his problems is to ask for his recommendations when he comes to us for help. This approach forces him to think through his problems to reach a conclusion. At times his lack of experience may produce inappropriate recommendations in which case we should help him find a better course of action. This whole process will strengthen the supervisor's judgment and his feeling of over-all responsibility.

Some readers may argue that the suggested approach would be time consuming, that it is far simpler to give the answer than to spend the time required to lead the supervisor to it. This is certainly true in the earlier stages of development. Remember however that any action on your part teaches the man some lesson. We teach him, by making his decisions, that he need not think through his problems because he can get solutions simply by asking. This attitude undermines any feeling of over-all responsibility and in addition might well require, on a long-range basis, even more time—20 years from now we will still be making his decisions.

Notice that the suggested approach differs from the "sink or swim" philosophy. Both methods seek to produce swimmers; both make use of deep water. However, I am suggesting that we give swimming lessons on the basis that, by so doing, we will lose fewer potentially good swimmers.

**3. Don't Undermine Him.** Undermining occurs in many forms. Let's consider one example of it to illustrate the suggestion being made.

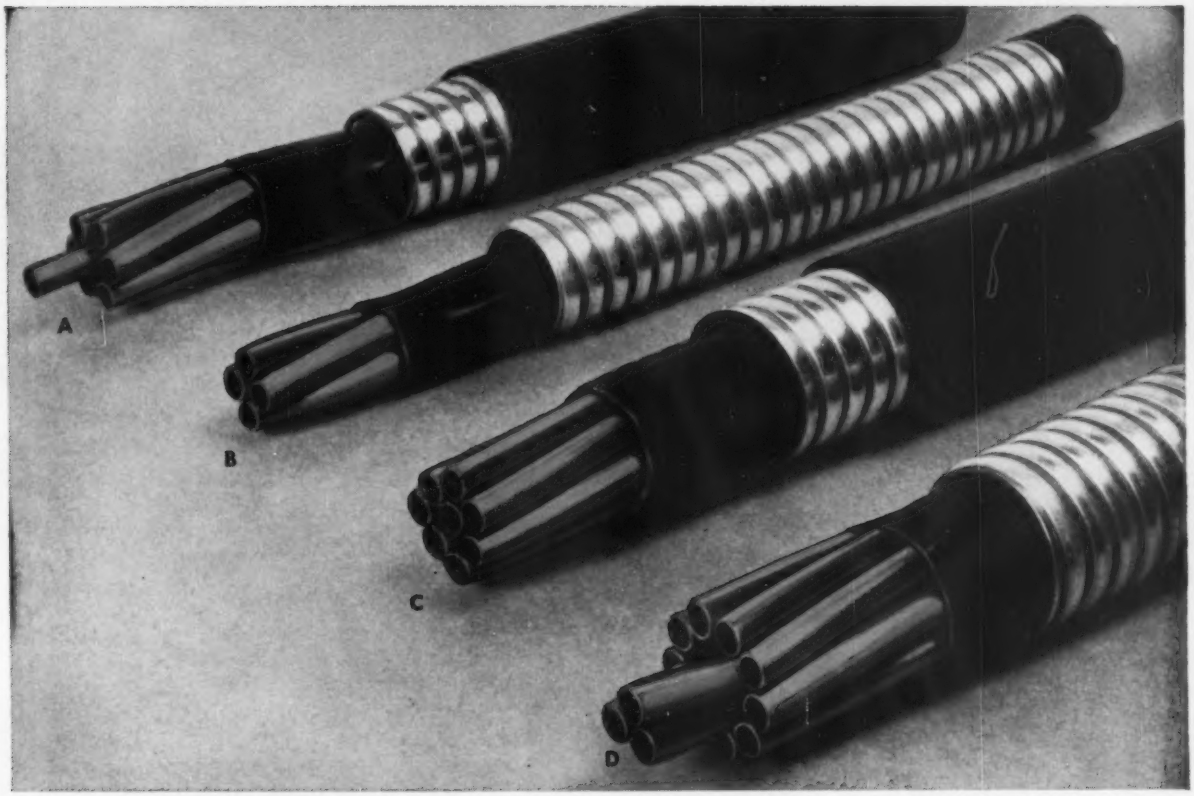
Quite probably there are some jobs which we will want to follow more closely than others. Our intertest will likely bring us into direct contact with the engineer involved, and, on occasions, we may feel that greater progress can be made if he redirects his efforts. The quickest and easiest approach is to redirect the engineer on the spot. If we do so, however, we have undermined our supervisor.

Consider the results. The supervisor will, in the normal course of his duties, discover that the engineer has changed his approach. Quite naturally he will want to know why. When informed, he will find himself in the awkward position of being held responsible for a job which he is not directing. This position is not in keeping with his concept of his job. If we persist with our behavior, the supervisor is likely to withdraw from active supervision because he feels that he is supervisor in name only—we are directing the effort. Or, he may quit. In either case we have lost the opportunity to develop a strong, responsible supervisor.

Certainly no one is going to argue that misdirected effort is tolerated simply to spare the feelings of the supervisor. The engineer must be redirected. The point under discussion is how the redirection is to be made. My suggestion is that we redirect the supervisor who can then discuss the matter with the engineer. By using this approach, we accomplish our immediate objective, we maintain the supervisor's feeling of responsibility and, we share some of our knowledge with the supervisor. Who could ask for more?

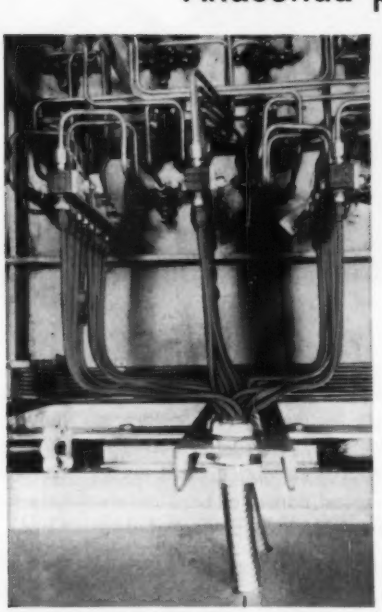
All this discussion assumes that we were right in the first place. Perhaps our supervisor will bring to light certain factors which we had overlooked. If this is the case, the merits of following the latter approach are even more obvious.

**4. Watch for Weaknesses.** Corrective action is most effective when it takes place at the time the weakness is first observed. Any delay, say even until a formal appraisal period, works to everyone's disadvantage. Carried to an extreme, the ridiculous situation might occur where a man with five years service is fired, the stated reason being that a certain weakness, observed during the first




**BAILEY ARMORTUBE** is available with *A*, thermoplastic sheath over steel armor; *B*, thermoplastic sheath under steel armor; *C*, thermoplastic sheath over and under steel armor; or *D*, with just steel armor.

# For its "Armortube" control system cables, Bailey specifies Anaconda precision copper tube in long coils



**A TYPICAL INSTALLATION** of Bailey Armortube in a large utility, indicating the large number of separate lines carried by two easily installed cables.

Armortube® flexible, armored, multiple-tube cable made by Bailey Meter Company, Cleveland, Ohio, has saved up to 40% of single-tube installation and maintenance costs in pneumatic, metering and control systems.

Armortube cable is available in lengths up to 1000 feet and in bundles of up to 19 individual ¼" O.D. copper tubes. Steel interlocking armor protects the tubes from mechanical damage and simplifies installation. In addition, various combinations of thermoplastic sheathing are available to provide further protection from moisture and corrosive atmospheres during and after installation.

**CLEAN AND DRY.** The copper tubes must meet rigid quality specifications, and Bailey has found that Anaconda copper tube consistently meets its requirements. Anaconda takes special care to see that inside surfaces are clean, smooth, and bright–free from dust, dirt, or metal chips which might interfere with the operation of delicate air and hydraulic circuits. Tube ends are sealed to keep out moisture and foreign matter during storage

**FLEXIBLE AND ACCURATE.** Anaconda copper tubes are uniformly soft, highly flexible–for easy bending during installation. And they are accurate in size and shape.

**LONG LENGTHS.** For applications such as instrumentation, Anaconda can produce copper tubing in coils up to 2200 feet for ¼" O.D.–up to 1400 feet for ⅜" O.D.–up to 1000 feet for ½" O.D.

**QUALITY TUBE AND CREATIVE TECHNICAL SERVICES.** Whatever your requirements for precision copper tubing–instrumentation or capillary tubing, or restrictor tubes – Anaconda specialists can help you find the most economical way to do the job. For such technical assistance, see your American Brass representative, or write: French Small Tube Division, The American Brass Company, Box 1031, Waterbury 20, Conn. 6068

**ANACONDA®**
**INSTRUMENTATION TUBING**



For more data on advertised products, use Readers' Service Cards, last page.

# Lights, camera, action

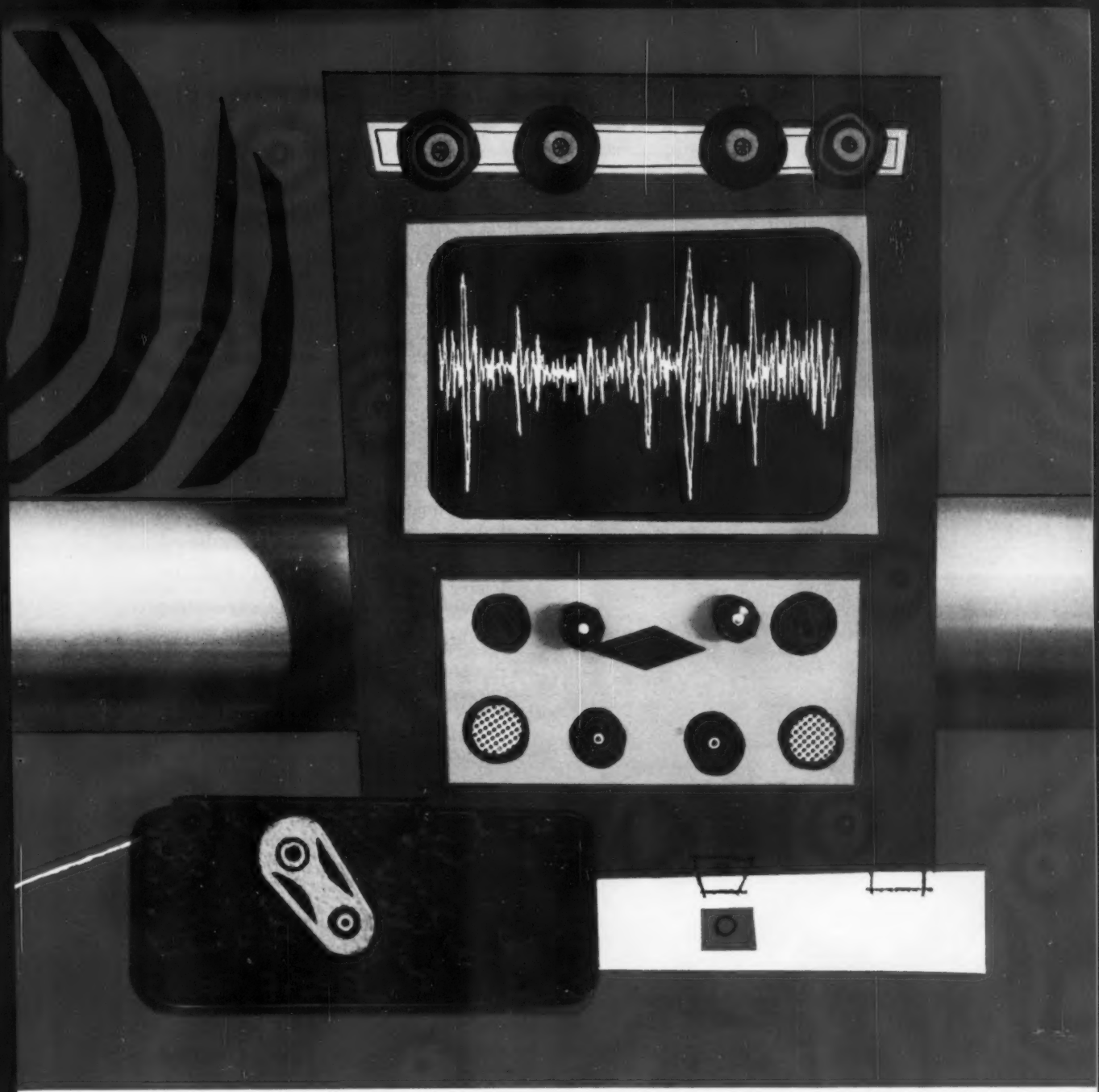
*National Tube tests USS National Electric-Resistance Welded Pressure Tubing with sound waves. This ultrasonic weld inspection process is tougher than a Hollywood screen test.*

This mark tells you a product is made of modern Steel.

As the tubing slides directly over a ground quartz crystal, electrical pulses are focused on the weld area. The crystal changes these pulses into ultrasonic vibrations which bounce off the weld and reflect its strength or weakness. The vibrations are speared by the crystal, converted back into electrical energy, and floated across an oscilloscope screen.

If a bad weld is reflected, the electrical current dances wildly on the screen and triggers an alarm system. The crooked pattern is pen-recorded on a graph, a bullfrog-voiced horn croaks loudly, and the tubing is squirted with black paint to mark the defect.

In case the ultrasonic unit breaks down, a red-faced dome



light automatically flashes, revolves and winks at the weld inspector. This blushing signal tells him that the unit needs to be repaired. It's added insurance that every length of tubing is completely tested before it leaves the plant.

Our inspection techniques are rigid. But they help us develop a high quality product for use in applications such as boilers, heat exchangers, condensers, superheaters, economizers and other types of heat transfer equipment. Consider USS National Electric-Welded Tubing for your next installation. Our trained Mill Service Force is available for field consultation. Write National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. *USS and National are registered trademarks*

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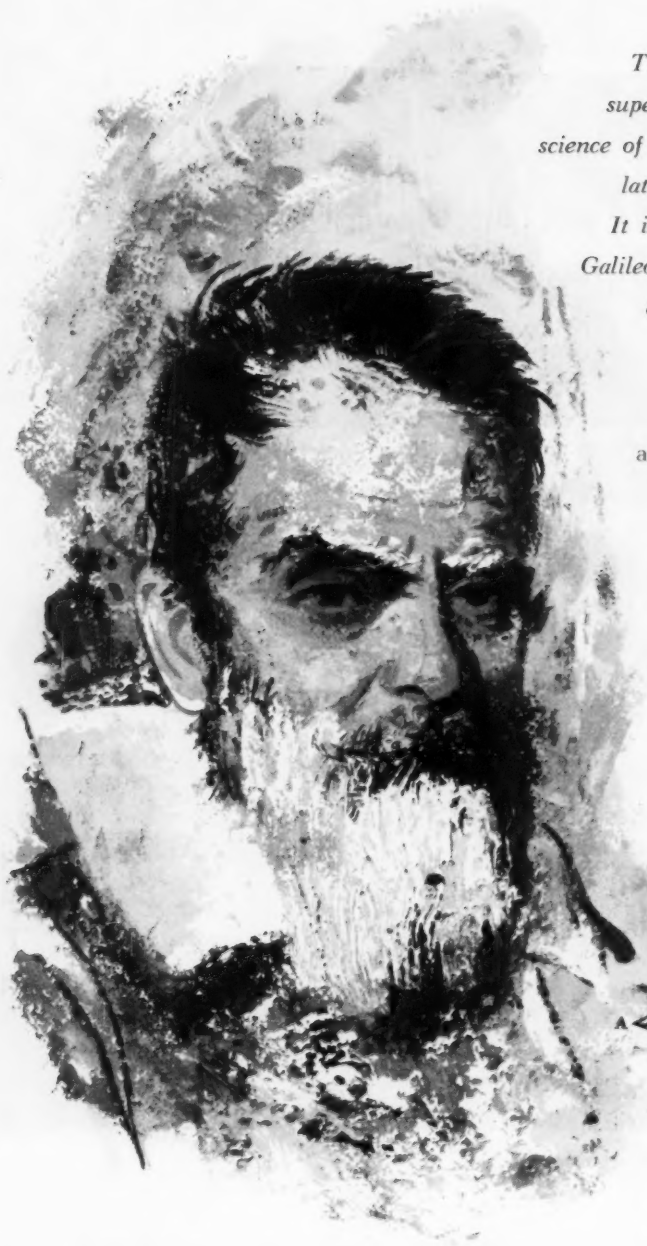
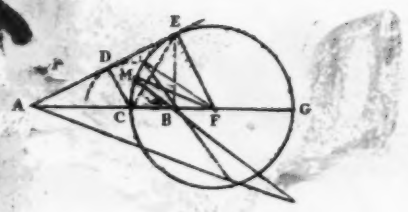
# THE QUALITY OF THINKING



*The mind of Galileo—keenly analytical, superbly trained—led him to founding the science of experimental physics, which, centuries later, is revealing the mysteries of space. It is self-evident by his achievements that Galileo's mind reached a level of quality far above ordinary standards of excellence.*

Within the same area of meaning, the quality of minds responsible for an engineering project can be evaluated only by results. When you check the record of Brown & Root's engineering through the years, the high quality of thinking reveals itself. Customer satisfaction from greater efficiency at lower costs has built a worldwide reputation for engineering and construction by Brown & Root.




**"The knowledge of a single fact through a discovery of its causes prepares the mind to understand and ascertain other facts..."**
*Galileo*

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year but never mentioned, has not been corrected.

One fairly common weakness, I suspect, among inexperienced supervisors is a subtle type of passing the buck. It could arise when an engineer asks about some personal matter, e.g., why he has not had a salary increase recently. The reason might very well be that he has not earned one. Will the supervisor have the courage to say so? We hope so.

He may however take the easy way out by saying that he had proposed it but the boss wouldn't approve or that, the personnel department is asking us to hold back or simply that, "they" won't let me. This latter behavior is obviously undesirable from any viewpoint and is certainly not in keeping with the concept of developing strong, responsible supervisors.

Select for promotion men who evidence strength and responsibility but be watchful lest they abandon these virtues under the pressure of a supervisor's job.

**5. Be Responsible for His Training.** This is indeed the age of the psychologist. He has told us how to raise our children and how they are to be educated. He has entered the market-place and determined, among many other things, the soap-box colors most attractive to the housewife.

The psychologist has also entered industry. He came with his battery of tests with which he can determine almost anything including, in some reported cases, the fact that the company president would not make an acceptable plant foreman. Other psychologists play the part of training directors who will initiate a supervisory training program (management development program to them) at the drop of a hint.

Seriously though, developing a new supervisor is a man-sized job, and any outside help is certainly welcomed. The company training director may be able to assist as he knows far more about the learning process than most of us ever will. He does however, from our viewpoint, present one serious limitation; he most likely has never worked in an engineering department. He probably can "talk" engineering but he has no feel for it. Therefore we must be careful to see that his limitation does not jeopardize any program he may devise.

The crux of the matter is that we are ultimately responsible for the performance of our supervisors. Any decision regarding a training program must be made with this fact in mind.

**6. Supervise Him as You Want Him to Supervise.** What suggestion could be more trite? But is it? Remember, we have promoted a capable, intelligent and aggressive engineer. We are only fooling ourselves if we do not recognize that our new supervisor will constantly be seeking to determine what we think is important so that he can pattern his behavior accordingly. His future, to a great extent, depends on it.

This prospect presents us with the disturbing fact that we too may need some development. Of course we can adopt the "don't do as I do, do as I say" attitude. All will agree, I believe, that this approach is not nearly as effective as setting a good example. The basic question remains: are *we* strong, responsible supervisors? # #

**About the Author**

**Howard L. Harrison** is an assistant professor in the University of Wisconsin's Mechanical Engineering Department, where he teaches in the Design Division. He specializes (both in teaching and in research) in the fields of automatic control and fluid power. Holder of B.S. and M.S. degrees in mechanical enginering from the University of Washington, Harrison was with Minneapolis-Honeywell Regulator Co., Minneapolis, from 1950-57. He was a design engineer, test supervisor and design supervisor for Honeywell, and joined the Wisconsin faculty in 1958.

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# Test Yourself on Labor Relations

## No. 1 Employe Wants Demotion

The company had a system of posting vacant jobs, and employes who felt that they could fill these jobs could bid for them. When a vacancy occurred in a semi-skilled job, the bidding notices went up. Management discovered that among those bidding was Mike Manning.

"Are you serious, Mike?" the personnel man asked. "You're getting more pay now, and you have a higher-rated job than the one that's up for bids."

"I sure am serious," answered Mike. "You see, I work the night shift and I don't like it. This lower job is a day job. Also I want a chance to learn a new trade. This lower job is right in line with what I want. I'll advance real quick and in no time at all I'll be making more than I am now. So, when do I start work?"

"I'm sorry, Mike, but you are ineligible to bid for this job. We post vacancies so that men could be promoted—not demoted."

Mike took his case to arbitration on the grounds that a senior man has a right to move down as well as up when he bids for an opening.

Management maintained that promotion could only mean *UP*.

## No. 2 Can Union Determine Number of Workers?

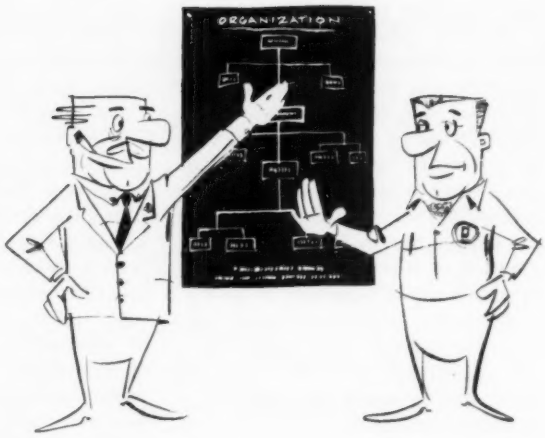
The company's agreement with the union had a clause which said that management had the right to determine the number of employes necessary for the "proper running" of its business. When management, because of poor business, gave notice of layoff to several employes, the union interceded.

"If you go through with this layoff, the remaining workers will have to work harder. They will be overburdened. You need more people to properly run your business. So you must cancel these layoffs."

Management didn't see it like that at all. "The number of people we need is our responsibility. If the remaining employes feel that they are overburdened, we'll take up that problem when we come to it."

**Test Yourself:**

Was the union RIGHT ☐ WRONG ☐




**Test Yourself:**

Was management RIGHT ☐ WRONG ☐

## No. 3 Rights of Steward

When supervisor Jonas needed someone to work overtime to complete a job, he assigned the task to Jay Raile, the senior man. When the shop steward, Joe Grimes, heard about this, he was pretty upset and complained to the foreman.

"Look here," Grimes said. "I've got the highest seniority in the department because as shop steward I outrank everybody else. The contract even says so. Read it."

The contract had the following provision: "Stewards, while serving as such, shall have top seniority standing. Stewards shall be given preference in employment in the departments in which they work."

The company didn't see it that way at all. Management maintained that top seniority for stewards applied only on layoffs and not on any other facet of the work schedule.

**Test Yourself:**

Was the company RIGHT ☐ WRONG ☐

**Answers on page 290**

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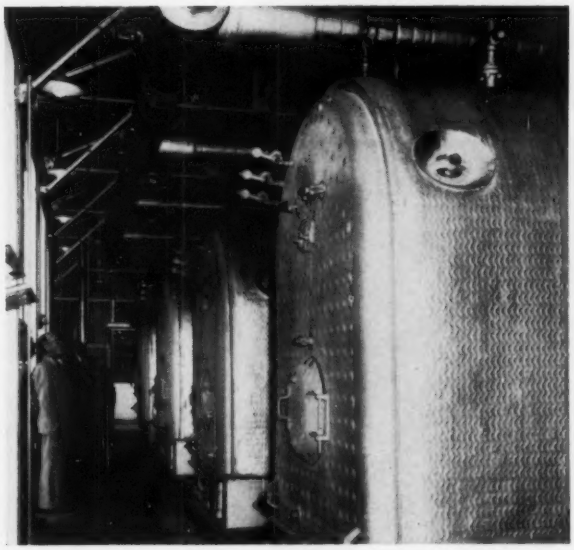
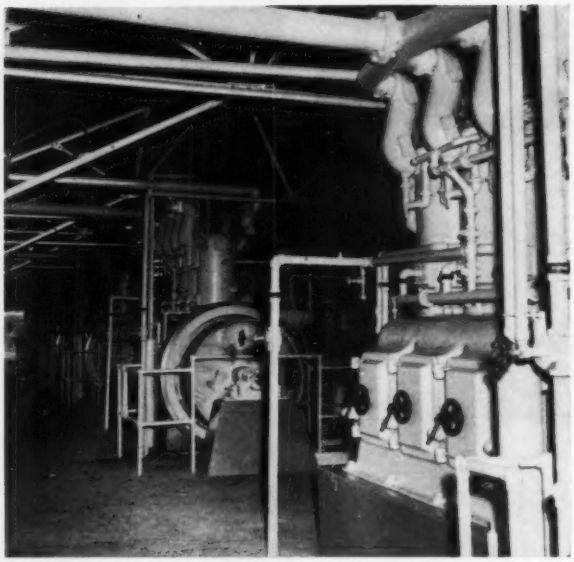
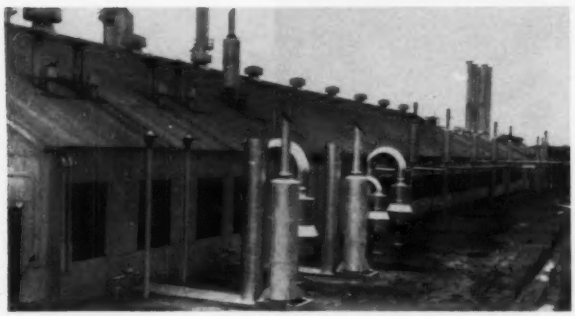


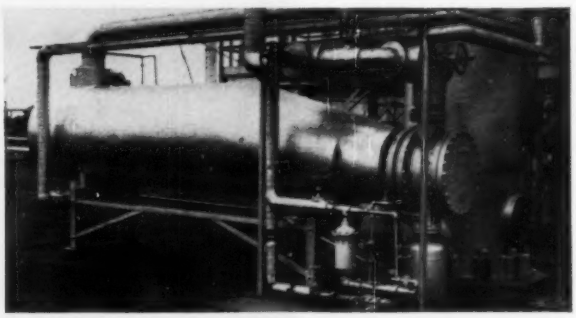
These boiler fronts operate at surface temperatures up to 850° F. Organic paints would not stick at all. Silicone-aluminum paints last a full year.



Surface temperature—600° F; Interval between paintings—two years. That's the story of silicone-aluminum paint used on this engine's exhaust stack.



Surface temperature of these silicone-aluminum painted engine exhaust snubbers runs as high as 500° F at the bottom, 400° F at the top.



This propane reboiler is repainted each time it is overhauled—but it would be impractical if paint didn't last at least two years at 400° F.

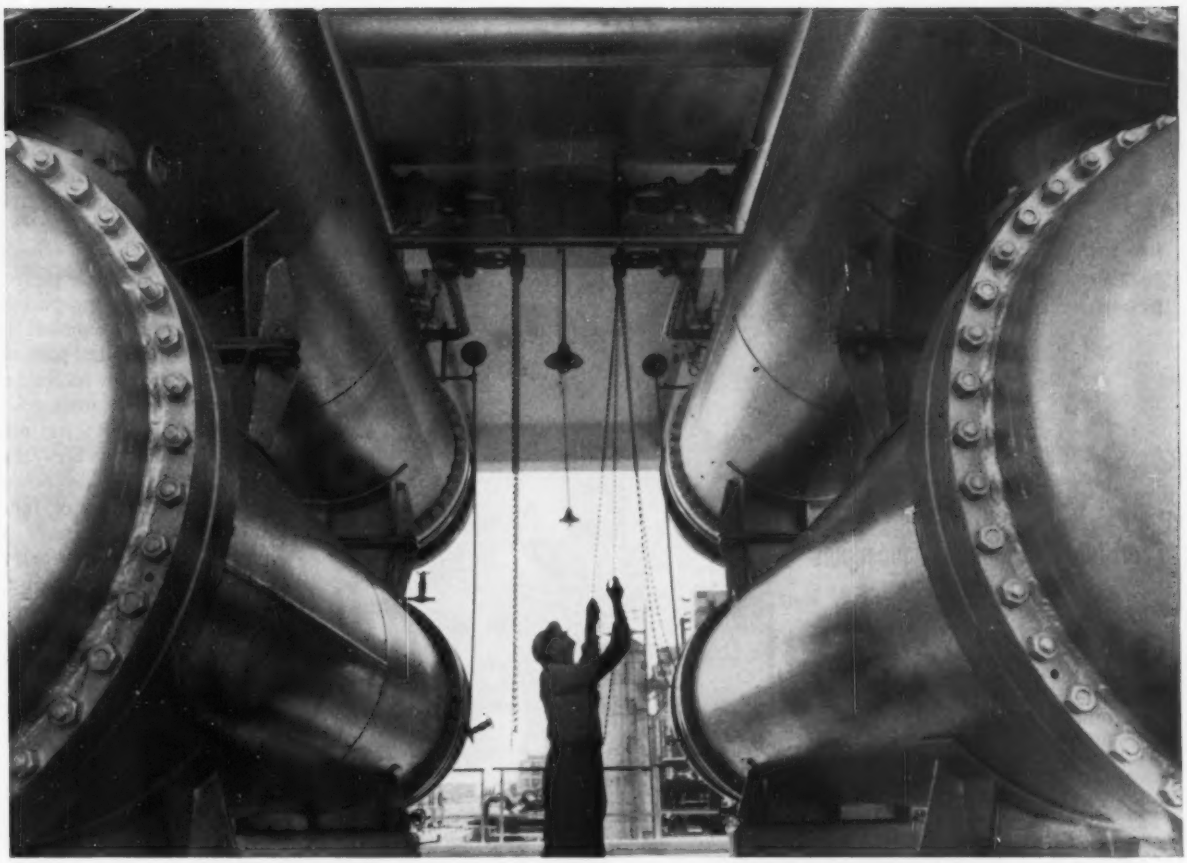
# Whip Hot-Surface Paint Problems

"If it operates at 300° F or above, paint it with silicones." That's the policy followed by maintenance men throughout the 16 gas products plants of Sinclair Oil & Gas Co. And that policy is backed up with more than eight years of experience in the use of silicone paints.

Rust can strip years of life from some process equipment—and such equipment is costly. Repair and maintenance operations are time-consuming and expensive too when repairmen must struggle with rust-frozen nuts and adjust screws.

Appearance is important too. Employes want to feel proud of their plant; pride promotes a "do-the-job-right" philosophy. Also, visitors and highway passersby are customers or prospects, and there's no sense offending them with blocks of rusty stacks and corrosion-spotted stills.

Until the silicones came along, however, many hot surfaces simply could not be painted. Outdoor boiler exhaust stacks, for example, run as hot as 600° to 650° F. Boiler fronts, though indoors, may operate 850° F. At various times organic-aluminum



At Cities Service refinery, Lake Charles, La. these condensers and coolers have linings of Monel alloy in the channels and floating heads. They have been in service for over 12 years.

# How Monel alloy solves the threat of brackish water

**Modern industry needs water** in vast quantities. It uses water for steam generation, for washing, cooling and conveying, and as an actual ingredient in manufactured products. Water costs are becoming a more important item in industrial production costs. In many areas where suitable cooling water supply is diminishing, industry has a choice of expensive purification or using the brackish or salt water that is available.

**The Cities Service refinery** at Lake Charles, Louisiana has reduced the overall cost of cooling with brackish water by the use of Monel* nickel-copper alloy. Monel alloy is an ideal material for handling these waters. It has long been recognized as a seagoing metal and has found widespread use for marine pumps, valves and propeller shafts.

Even in contact with salt water at high velocity – as in condenser tubes and in pump impellers – Monel alloy resists the effects of cavitation and erosion. *Monel alloy is free from chloride ion stress-corrosion cracking* . . . even under conditions of total immersion, intermittent wetting and drying or vapor phase exposure, and in the presence of residual welding or applied stresses and crevices.

And here's something else. Monel alloy is strong and tough, yet it can be readily fabricated, welded and machined. No stress relieving treatment after forming or welding is needed to develop maximum corrosion resistance.

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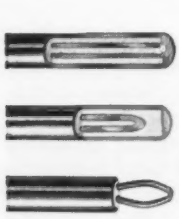

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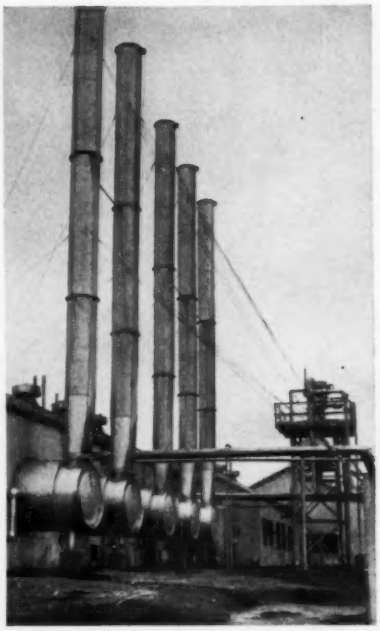
## *How To Do It . . .*



**Organic-aluminum paints wouldn't stay on these boilers and stacks. Silicone-aluminum paint not only sticks, but protects against corrosion.**

paints were tried on these surfaces but they blistered quickly, sometimes as soon as the units came up to operating temperatures. This produced a double problem: corrosion, as bad as before, plus blistered, blackened remains of the paint.

The solution to the problem came in 1950. Sinclair chemists developed a silicone-aluminum formulation which, in preliminary tests, looked almost too good to be true. Samples were sent to several plant managers for actual trials. The results were a revelation! The silicone-aluminum paint stayed on in spite of heat, in spite of weathering. It looked good. And, most important, it stopped corrosion.

On the boiler exhaust stacks, where no organic paint would stick at all, the silicone-aluminum paint lasted well over a year. And when the time finally came to repaint, it was clear that the silicone-aluminum film, though worn, still adhered strongly to the steel, still maintained its protective action. Repainting was carried out right over the old film without any need for scraping, chipping or sandblasting the surface.

Although painting is of the greatest importance, no plant superintendent likes to lose production time due to repainting operations. At Gas Products Plant No. 2, two techniques save much production time, yet allow the plant to look its best at all times. Both of these techniques make use of the unusual high temperature properties of the silicones. First, equipment is always repainted as a regular part of cleaning or overhaul shutdowns. Sometimes this means that a surface is repainted before it needs it: the old film may have months of life left. However, because the silicone wears from the outside in (instead of failing through flaking or blistering) a built-up film gives proportionally longer life; no paint is lost. Second, surfaces to be repainted in service are cooled only to about 250° F before repainting. This production-saving technique has been tried with organic paints on some cooler surfaces, but it doesn't work. The organic paint just won't stay on.

The silicone paints not only withstand heat, but actually thrive on it. The painted surface should attain a temperature of at least 300° F to properly cure the paint film. Without this cure, the coating doesn't attain its full hardness and durability.

A study of maintenance costs shows that silicones save money in spite of the relatively high materials cost, even in the cases where Sinclair would previously use organic paints. Why? Well, Sinclair now has fewer repaintings. And that means much lower labor cost. Even the hottest surfaces (800° to 850° F) go about a year between paintings. Other surfaces average between 1½ and 2 years. Surface preparation time is reduced, too; there's a lot less scraping, sandblasting, and chipping to do.

Success with the original silicone formulation led to the use of a silicone black paint as well. This formulation, although not quite as heat stable as the silicone-aluminum paint, has one advantage. It is designed to form a film of acceptable hardness and durability at lower curing temperatures than the aluminum formulation.

This story was submitted by Dow Corning Corp. with approval of Sinclair Oil and Gas Co.

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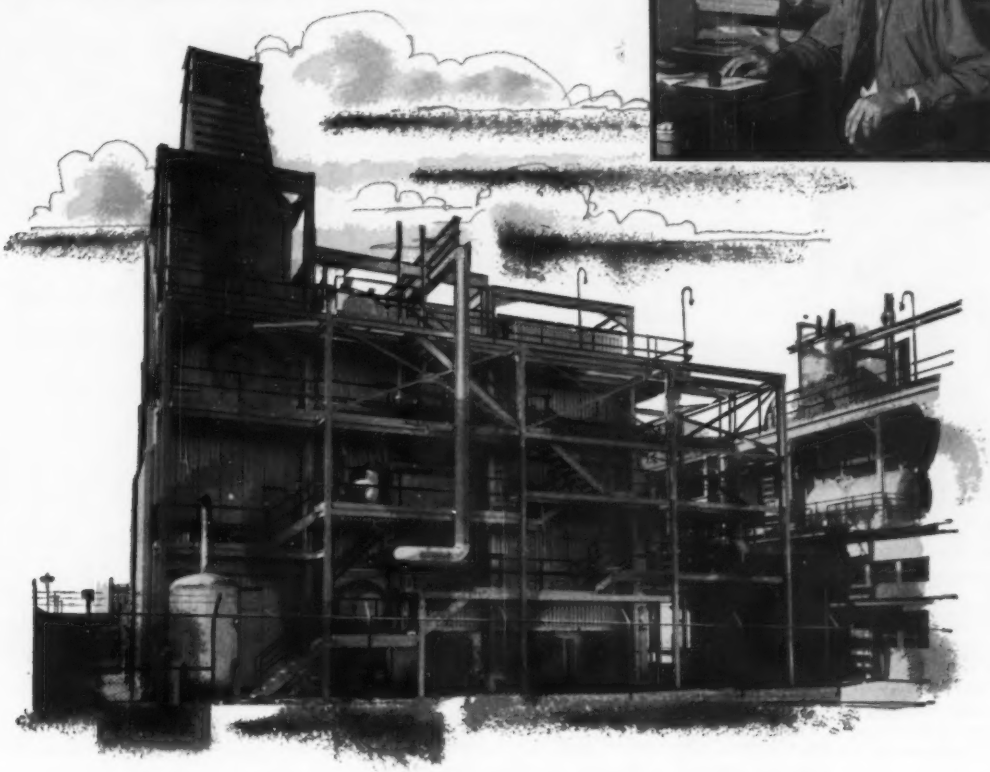

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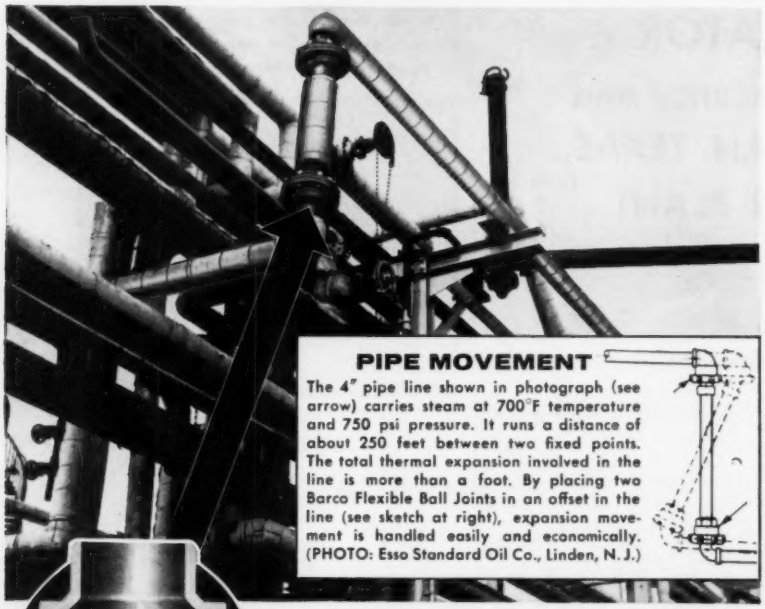
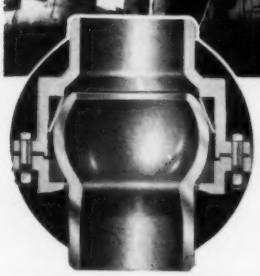
**WICKES BOILER CO., SAGINAW 18, MICHIGAN, DIVISION OF THE WICKES CORPORATION**

# How Refinery Handles 700°F. STEAM . . . PIPE EXPANSION



**PIPE MOVEMENT**

The 4" pipe line shown in photograph (see arrow) carries steam at 700°F temperature and 750 psi pressure. It runs a distance of about 250 feet between two fixed points. The total thermal expansion involved in the line is more than a foot. By placing two Barco Flexible Ball Joints in an offset in the line (see sketch at right), expansion movement is handled easily and economically. (PHOTO: Esso Standard Oil Co., Linden, N. J.)



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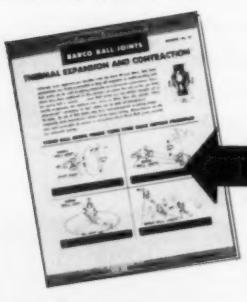


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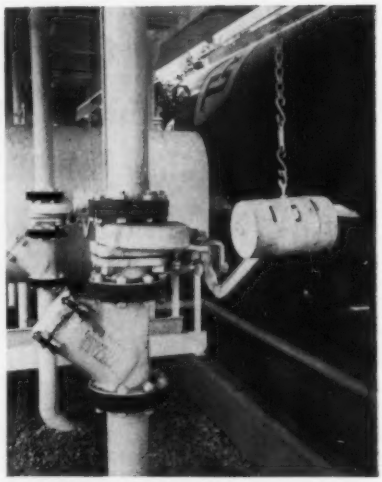

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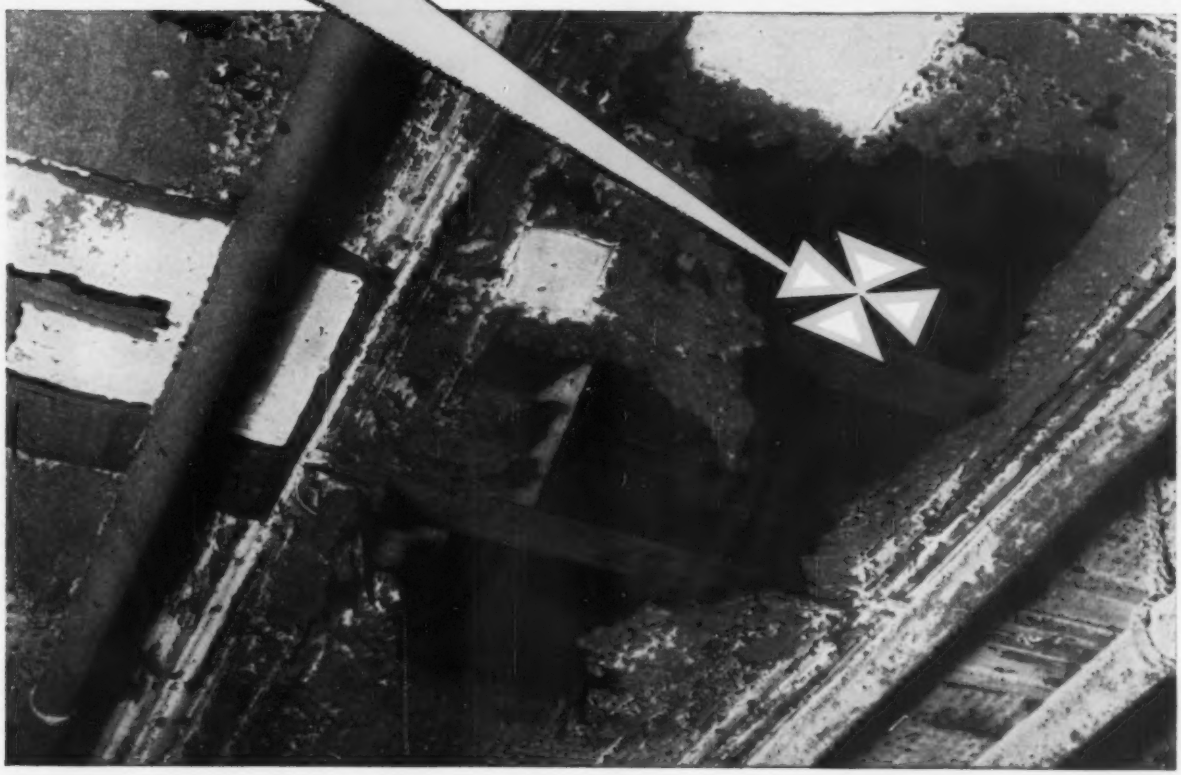
# "X" MARKS THE SPOT

## where a $1.05 saving went through the roof!



On a 250 gallon paint order, the Plant Maintenance Department figured to save $1.05 per gallon by using a paint that was cheaper, and "just as good" as Tygon. The cheaper paint *appeared* to be doing a good job — then the roof fell in!

These people learned the hard way what most corrosion engineers already know: the cheapest paint rarely gives the most economical protection. Where proven corrosion resistance is concerned, it's virtually impossible to find a paint that offers lower *cost per year per square foot of protection* than Tygon Paint.

Tygon Protective Coating Systems are designed for practical application of specialized protection against a wide range of specific corrosives and exposure conditions. The broad Tygon line includes vinyl-based coatings, as well as formulations based on epoxy resins. Depending upon the specific use for which each coating is designed, Tygon Paints provide more effective, longer-lasting protection against such corrosives as acids, alkalies, oils, water, alcohols and many solvents. Tygon is available for simplified, economical application by brush or cold spray — and in the Tygon "ATD" Series — by hot spray methods.

Properly applied and used under the specific conditions for which they are recommended, Tygon Coatings will outlast and out-perform practically any other paint available today.

Write for this free Tygon Data Book. It gives complete application details plus helpful information on resistance of Tygon to over 150 corrosives.

PLASTICS & SYNTHETICS DIVISION

**U. S. STONEWARE**

**AKRON 9, OHIO**

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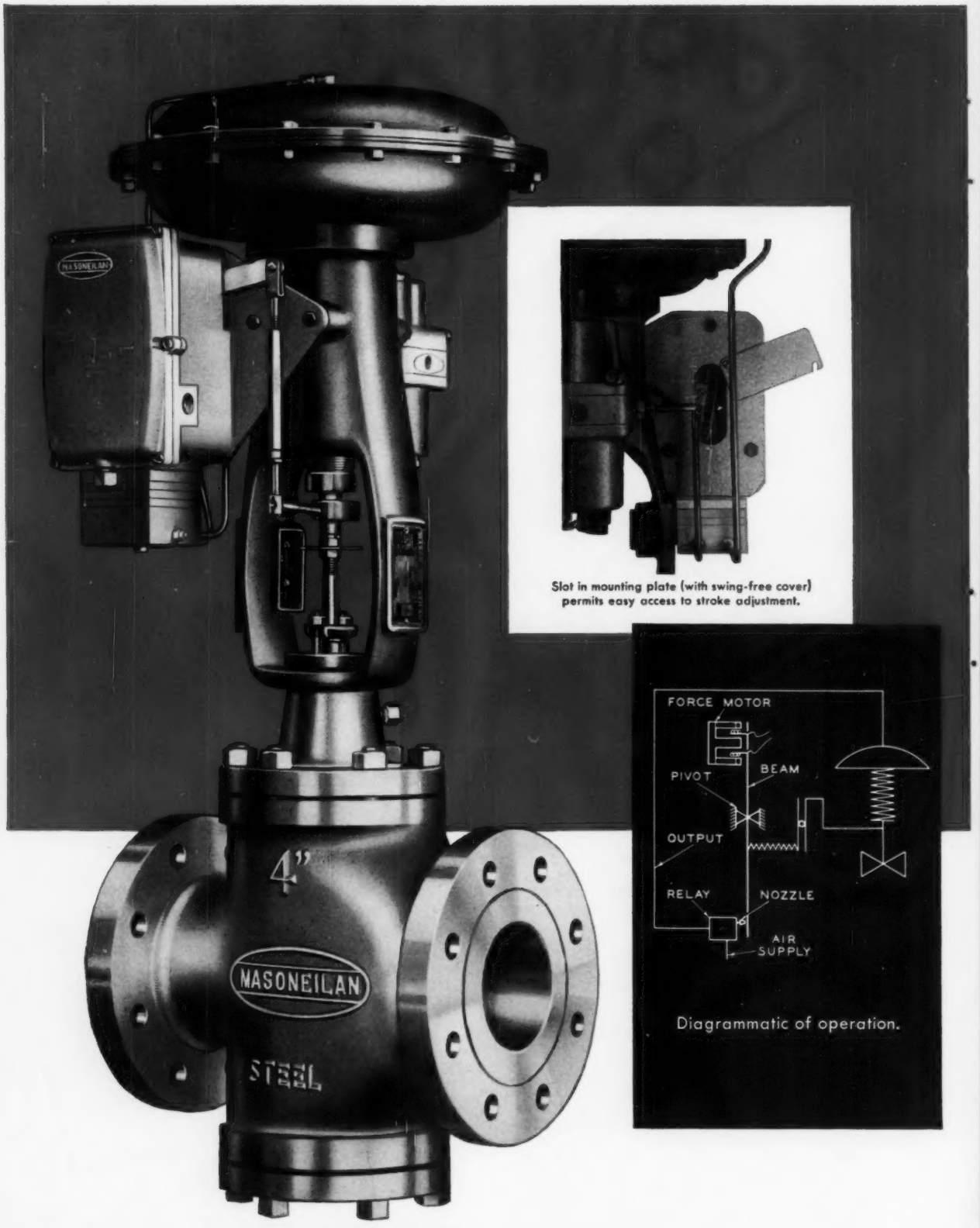



Model 8010 mounted on spring-diaphragm actuator. Note compact design.

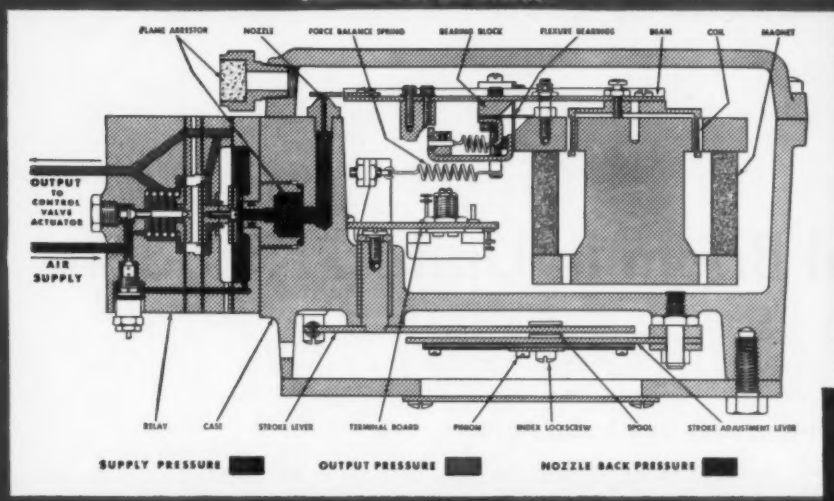


Slot in mounting plate (with swing-free cover) permits easy access to stroke adjustment.




Diagrammatic of operation.

Schematic of air circuits.




**Speed** The speed of the positioner, with integral relay and normal 20 psi supply pressure, is tabulated below.

| ACTUATOR SIZE | VALVE STROKE (inches) | SPEED (seconds) |
|---|---|---|
| 9 | ½ | 1.5 |
| | ¾ | 1.8 |
| 11 | ¾ | 2.8 |
| | 1 | 3.3 |
| 13 | 1 | 4.9 |
| | 1½ | 6.3 |
| 15 | 1½ | 9.4 |
| | 2 | 11.4 |
| 18 | 2½ | 21 |
| | 3½ | 29 |
| | 4 | 32 |

## Performance Data

Open-loop Gain* — approximately 100
Linearity — within ±1% of full stroke
Repeatability — within 0.2%
Load Sensitivity — Output pressure change of 1.2 psi per 0.1% of full stroke offset
Supply Pressure Effect — ±1% of full stroke for ±5 psi change from 20 psi

# Now! Masoneilan E/P Positioner with Stem Velocity Feedback

## Combines high open-loop gain and closed-loop stability to give you Precise Positioning and Superior Dynamic Response

The new Masoneilan Model 8010 Electropneumatic Positioner offers optimum performance plus these design advantages:

- A true positioner — *direct* comparison of valve stem position with controller output signal provides dynamic response and positioning accuracy not obtainable with transducer and pneumatic positioner combination.
- Electrical circuit easily adapted to a variety of controller output signals.
- Extra large stabilized magnet, plus efficient magnetic circuit, provides high force changes.
- Explosion-proof construction meets requirements of Class I, Division I, Group D.
- External stroke adjustment accessible without removal of cover — no exposure of electric wiring.
- High capacity relay for fast stroking speeds. Relay may be mounted in any one of four positions to facilitate piping.
- Balanced beam permits installation of valve in any position without shift in calibration.
- Available for 3-15 psi or 6-30 psi valve spring ranges and for split-ranging. Standard stroke ranges ⅜"–3" and 2"–4". Others available.
- Available with direct or reverse action and for direct or reverse actuators.

You can now utilize the desirable characteristics of electronic control and obtain the power and smooth throttling action of pneumatic valves by using Masoneilan Model 8010 E/P Positioners. Full details on request. Ask a Mason-Neilan representative or write direct —

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*Sales Offices or Distributors in Principal Cities in United States and Abroad*

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## *Who's Building...*

# Petrochemical Boom in United Kingdom

**Production of petroleum-derived chemicals is growing at about 6 percent a year. Output is expected to increase to 2.7 billion pounds by 1961**

FOLLOWING A PATTERN similar to that of the United States, although not starting until the late '40s, United Kingdom petrochemical production is growing at about six percent per year. British output of organic chemicals increased about 40 percent per year between 1950 and 1957—and is still expanding. Plastics production in 1958 increased more than 20 percent to a total of about one billion pounds.

**Petrochemical Production.** Total petrochemical production has grown from about 1.3 billion pounds in 1958 to 1.5 billion pounds in 1959 and is expected to increase to 2.7 billion pounds by 1961.

Already these petroleum based organic chemicals have taken more than 40 per cent of the market and this trend is expected to continue. Demand for petrochemical products is running far ahead of production even with this rapidly expanding building program. Because of the handicap of importing petroleum feed stocks and the late start, petrochemical expansion is on a relatively small base.

**Refinery Capacity.** Likewise, refining capacity has increased from a prewar level of 50,000 bpd to a present capacity of more than 800,000 bpd. With continuing dependence upon petroleum base stocks for raw materials, organic chemical production is expected to increase by two and one-half times by 1970. Accompaning this increase in organic chemical production, innorganic output is up about 40 percent over present levels.

**Plastics.** British consumption of plastics is still below that of the United States and Germany, even though consumption is growing rapidly. Plastics output will likely be around 2.5 billion pounds by 1970, of which about 70 percent will be thermoplastic types—polyethylene, polyvinyl chloride, polystyrene and polyacrylics. However, it is felt that polypropylene will get some share of this future market. Total plastics sales were about $160 million in 1959 with the lion's share going to polyethylene ($60 million). Polyvinyl chloride and polystyrene sales were $30 million each, and acrylics and cellulosics $20 million each.

**Polyethylene.** This dynamic growth thermoplastic was actually discovered by British scientists, with Imperial Chemical in the early '30s. Since then, its growth pattern in the United Kingdom has paralleled closely that in the United States. Its sales in 1958 were a third higher than the previous year, although total plastics grew at a rate of only seven percent. ICI leads the field in polyethylene production with 180 million pounds in 1959. However, this production rate currently is being increased to 210 million pounds.

Union Carbide is doubling its Grangemouth facility from 30 million pounds to 60 million pounds by the end of 1960. Monsanto's 20-million-pound-per-year plant is already greatly expanded. Shell Chemical Co., Ltd., has just started construction of a 60 million-pound-per-year plant to produce a wide range of polyethylenes and polypropylenes. Some experts estimate that polypropylene production will be 20-24 million pounds per year of Shell's capacity.

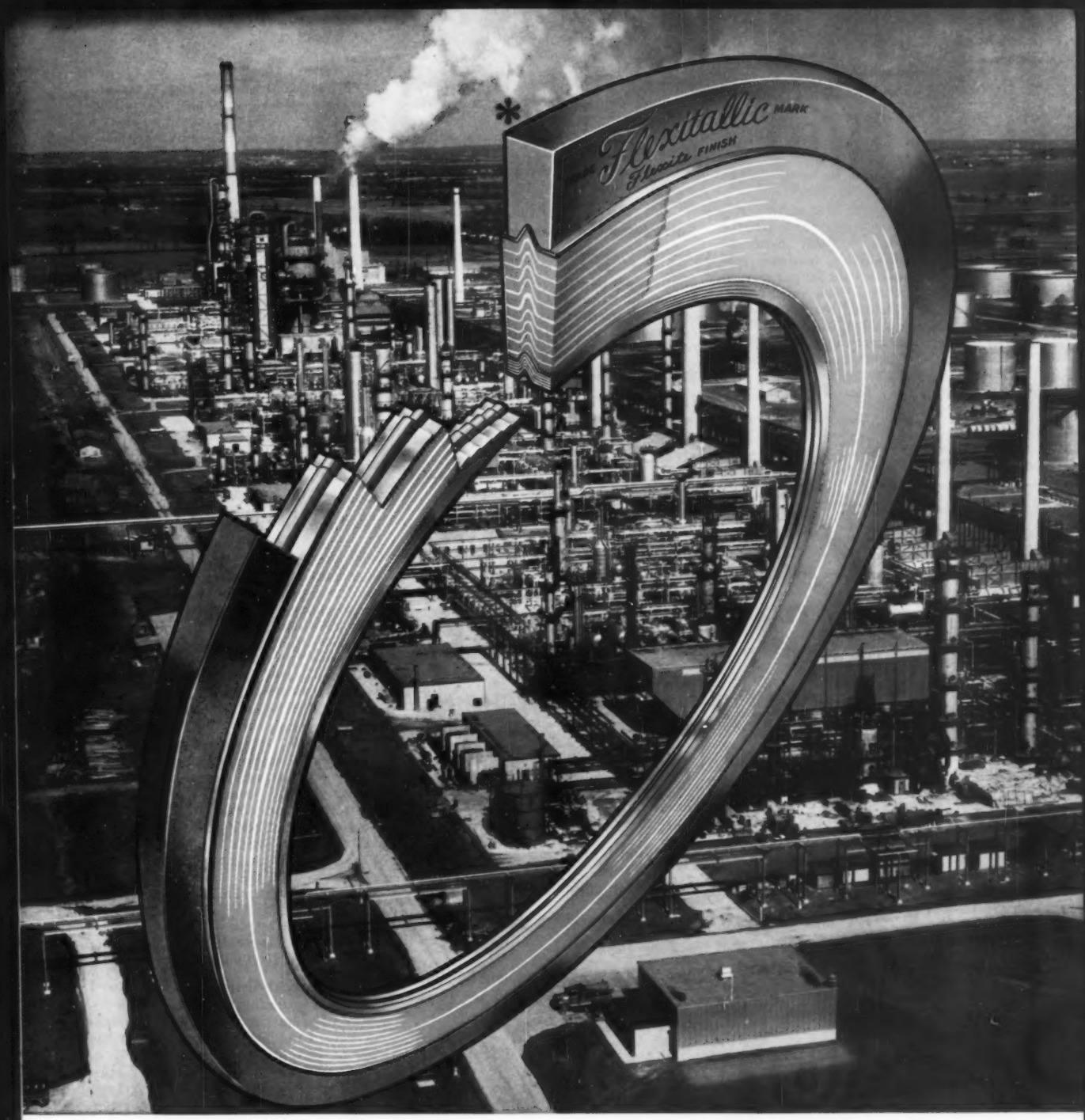
British Hydrocarbon Chemicals started a 24-million-pound-per-year polyethylene plant in 1959 using the low pressure Phillips process. Shell chemical is also in the low-pressure field using the Ziegler process.

**Polypropylene.** ICI has under construction 20-million-pound-per-year plant for polypropylene. Also Shell has a montecatini license for polypropylene.

**Polyvinyl Chloride.** With polyvinyl chloride sales currently running about $30 million per year, ICI recently announced plans for a 20-million-pound-per-year expansion to its 140 million pound per year production. This production is up from 110 million pounds in 1958. British Geon, Distillers unit, is the other major PVC producer.

Reichhold Chemicals, Ltd., also is entering the PVC field with a new compounding plant. This new activity will demand a substantial hike in the productive capacity in the next few years.

While British PVC is still principally coal derived (acetylene from carbide), the growth in ethylene capacity, and in particular plans for an theylene dichloride unit by British Hydrocarbon Chemicals, Ltd., may

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SPIRAL-WOUND GASKETS
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## *Building . . .*

open up PVC production to the petroleum base.

**Synthetic Rubber.** Because of vast holdings in natural rubber plantations, British entry into synthetic rubber was late in starting. Starting in 1958 with the completion of International Synthetic Rubber Co., Ltd.'s plant, synthetic rubber now accounts for over 30 per cent of the 238,000 tons of British rubber consumed in 1959. (United States consumption of synthetic rubber is about 64 percent of total rubber consumed.) Since 1958, which marked the British entry into the styrene-butadiene synthetic rubber industry, other types of synthetic rubber have been produced and a new neoprene plant is in production in Northern Ireland. Shell has plans for a polyisoprene rubber plant.

Other actives in the synthetic rubber field are ICI, Monsanto, and E. I. du-Pont de Nemours & Co.

**Butadiene.** Currently, most of the butadiene is supplied by Esso Petroleum Co., Ltd., at its Fawley refinery near Southampton. Production is currently running at about 40,000 tons per year of butadiene. British Hydrocarbon Chemicals also plans to double its butadiene production.

**Styrene.** Forth Chemicals, Ltd. (owned by British Hydrocarbon and Monsanto) currently produces about 60 million pounds per year of styrene and plans to double this production by the end of 1960.

**Synthetic Detergents.** The purported beginning of the petrochemical industry in Britian was by Shell with its introduction of synthetic detergents. This began at the Stanlow refinery in 1942. In 1956, Shell began production of alkyl benzene at Shell Haven and now markets its production to detergent manufacturers. In 1959, synthetic detergents captured more than 33 per cent of Britain's detergent-soap business. (This compares with a U.S. total of 75 percent total synthetic detergents.) In Britain synthetics should account for more than 40 percent of the market by 1970.

British Hydrocarbon also produces synthetic detergents at its Grangemouth plant, called Grange Chemicals (a joint venture with Oronite Chemical Company).

**Olefins and Olefin Chemicals.** Esso Petroleum Co., Ltd., started the supply of ethylene in Britain from its Fawley refinery. It is currently supplying ethylene to Union Carbide for its 46-million-pound-per-year ethylene derivatives plant. Esso will also supply ethylene to ICI's planned $14-million ethylene glycol and oxide plant at Sevenside. In addition to supplying butadiene to International Synthetic Rubber, Esso also pipes ethylene to Monsanto's polyethylene facility. This all comes from Esso's 80 million pounds of ethylene production. Currently projected for construction by Esso is a $15.5-million expansion for more production of ethylene, butene and propylene.

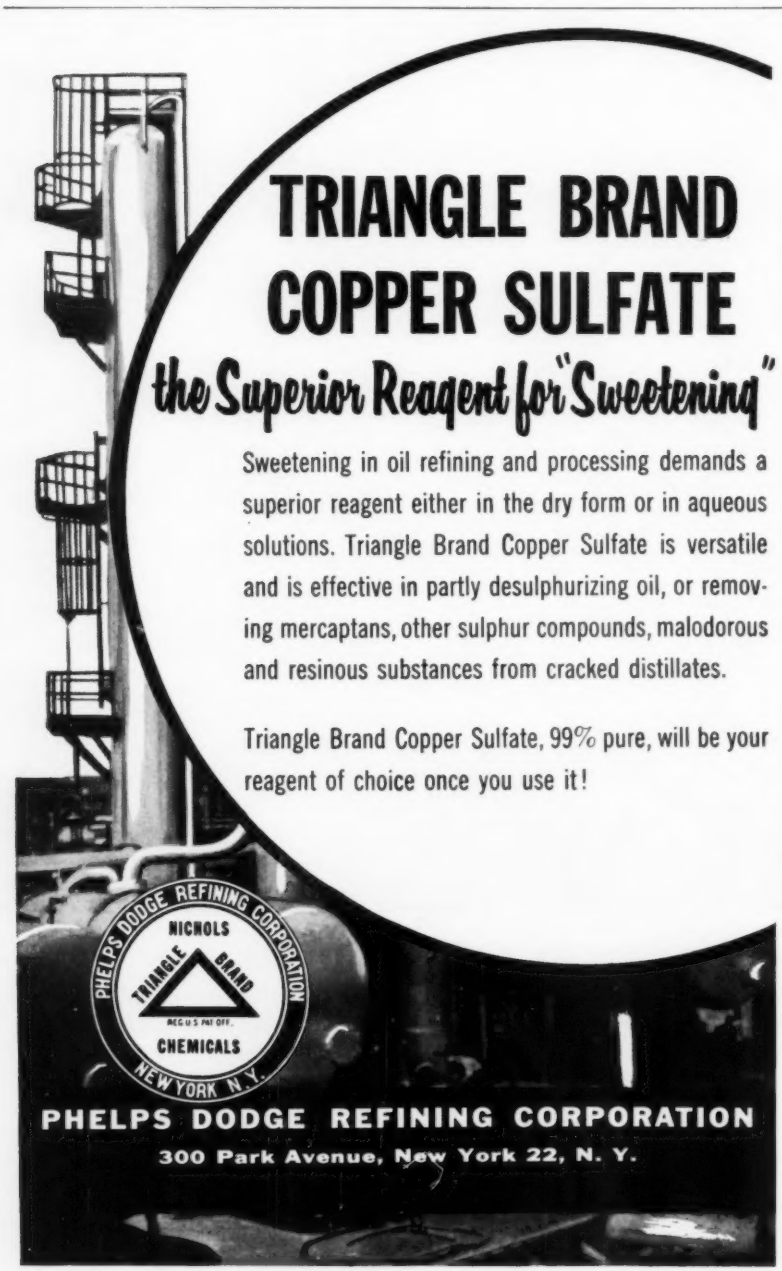
British Hydrocarbon Chemicals is building its third ethylene plant at Grangemouth, which will double olefins production and make the largest unit of its kind outside the United States. Also planned are units which will double production of butadiene, and new plants for methynol and ethylene dichloride. Soon British Hydro carbon's total investment should exceed $100 million.

**Other Petrochemicals.** It is rumored Oronite is planning two aromatic petrochemical plants in association with British Petroleum. Estimated to cost in excess of $25 million, one project is in Britain and the other in Germany. They are supposed to produce othro-xylene, para-xylene, benzene and ethylbenzene.

This feverish expansion of petrochemicals has had its effect on British chemical investments. With only five petrochemical plants in 1953 valued at $109.2 million, now there are 15 petrochemical plants with an investment of more than $394 million.

In 1958, plants started producing glycol, high and low-pressure polyethylene and synthetic rubber. Since then, plants for production of synthetic alcohols, ethylene, polyethylene and other ethylene-derived petrochemicals have been constructed and started.

As the British become more and more dependent upon petroleum for chemical production, and with no domestic pro-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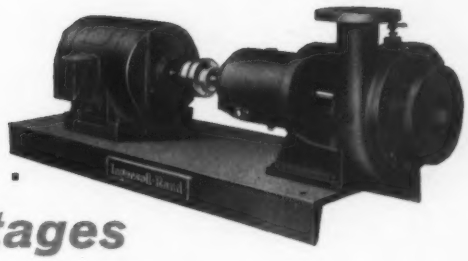
# cradle-mounted pumps for any application . . .

## *all with these basic advantages*



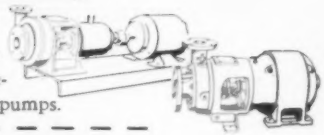
Simplicity of design, rugged construction, careful material selection and expert workmanship enable Ingersoll-Rand cradle-mounted pumps to meet the highest performance standards, year after year, with minimum attention or maintenance.

Built in sizes through 100 horsepower, deliveries range to 3200 gallons per minute, heads to 525 feet. Single or two-stage models available with threaded or flanged intake and discharge connection.

Call on your nearest Ingersoll-Rand pump specialist to help with your liquid-moving problems. There are standard or engineered units to suit any requirements.

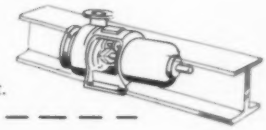
**interchangeability**

— hydraulically and physically, the pump ends are interchangeable with I-R Motorpumps.



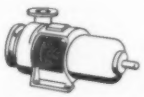
**maximum strength**

— barrel type construction gives greatest rigidity and perfect alignment.



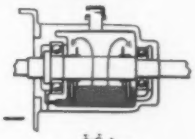
**accessibility**

— large side openings provide easy access to stuffing box.



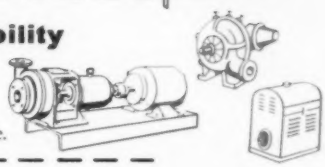
**effective bearing lubrication**

— ring-lubricated bearings easily handle radial and axial loads.



**driver flexibility**

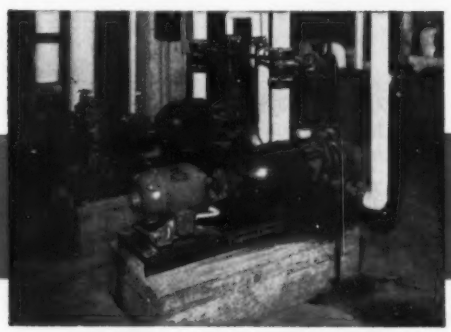
— permits use of motor, turbine, engine or belt drive.



*a century* **1860 – 1960** *of pump progress*

*from the leading manufacturer . . .*

A turbine-driven cradle-mounted pump and a motor-driven standby in a manufacturing plant power house.



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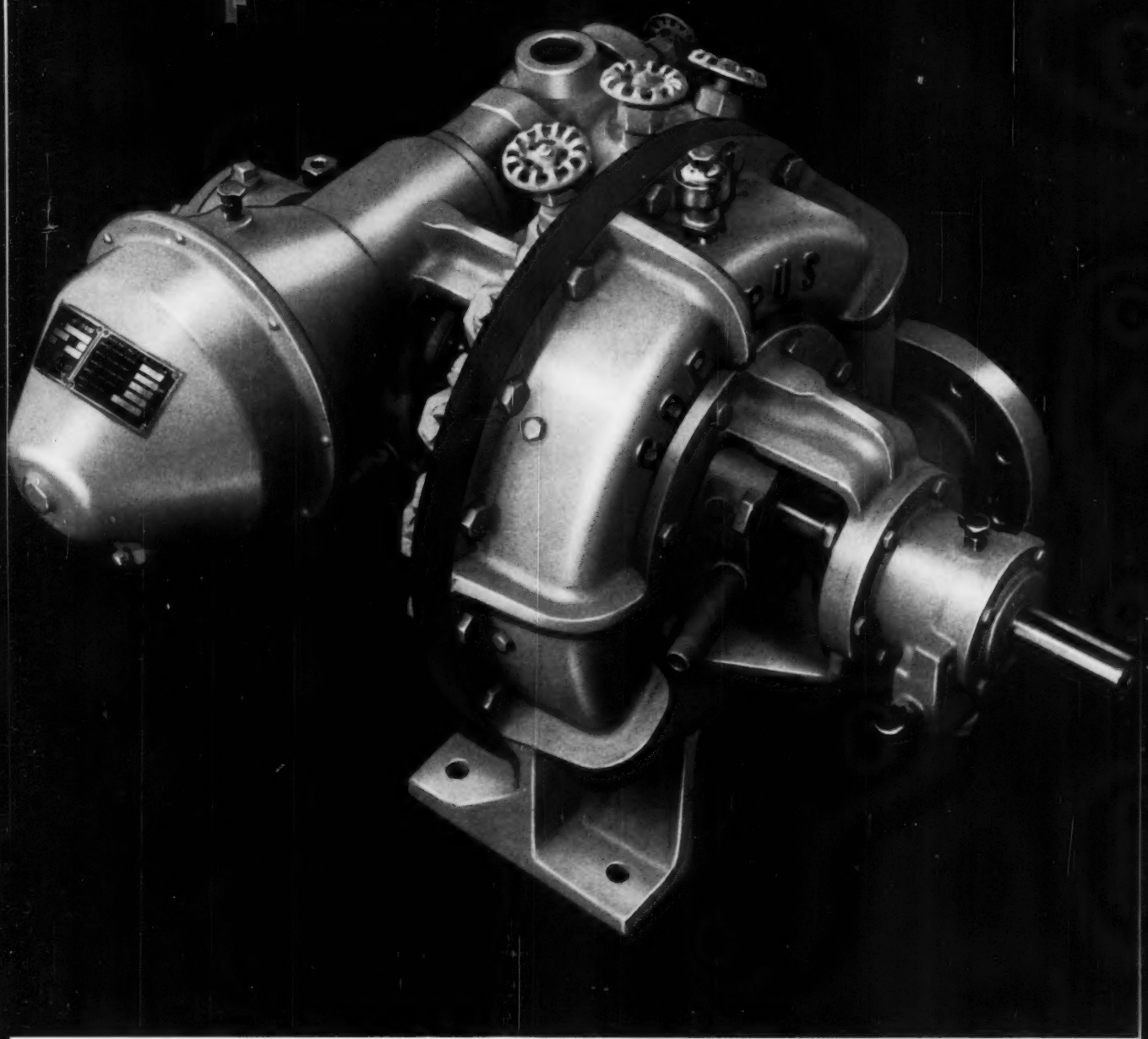

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*A totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.*

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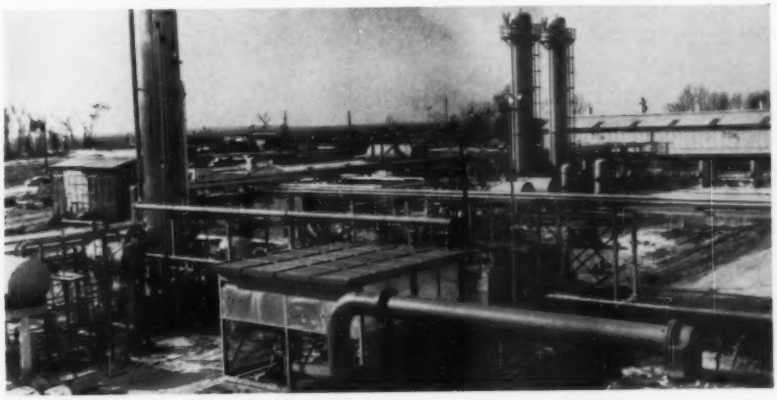
duction of this vital raw material, there is an intense interest in better and cheaper ways in which to transport petroleum materials. Liquid ethylene is now moved by tank truck, and movement of liquid methane, ethane, butane and propane by tankers is currently being studied.

Coal and the fermentation industry have been hard hit by the advent of intensive activity in petrochemicals. Ethyl alcohol, acetone and butyl alcohol from fermentation of grain and molasses has declined. These operations are being replaced by petrochemical plants which produce the products cheaper.



**New Louisiana unit extracts hydrocarbon condensate, natural gasoline and propane gas.**

## Shell Oil's Weeks Island Plant Completed

Shell Oil Co.'s Weeks Island, La., gas cycling and processing plant, under construction the past 15 months, is on stream —recovering three hydrocarbon liquids from natural gas. The 120-MMcf-per-day unit extracts hydrocarbon condensate, natural gasoline and propane from gas removed from three gas wells and a number of oil wells.

Cycling involves bringing gas to the surface, stripping it of liquids and returning it under pressure to the same formation. This process provides the pressure for lifting oil to the surface from 33 producing oil wells. By removing these liquids now rather than waiting until the oil is depleted, Shell expects to obtain about 27 percent more liquid production from the formation.

Condensate is recovered from the cycled gas through separation. Then the gas is combined with oil-well gas produced in the Weeks Island field, and natural gasoline and propane are removed through an absorption process. This oil-well gas previously had been sold with its liquids intact.

**Big Port Arthur center will occupy 35.2 acres of land.**

## $7.5-Million Research Center for Texaco

A new multi-million dollar research center will be constructed by Texaco Inc., at Port Arthur, Texas, location of the company's largest domestic refinery. Construction will cost an estimated $7.5 million and will require five years to complete. The new project will provide Texaco with a second major petroleum

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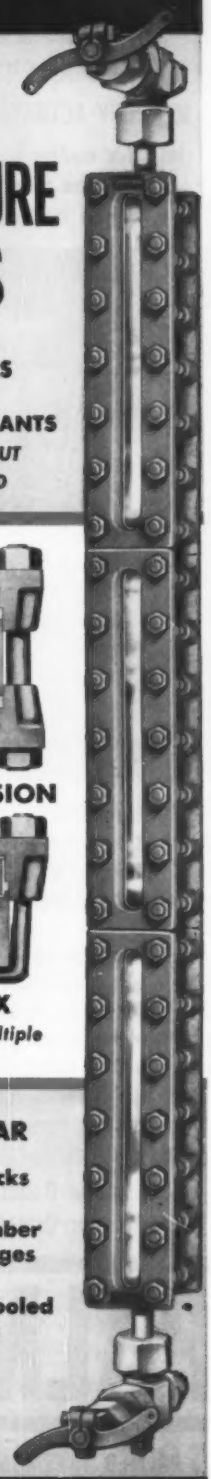

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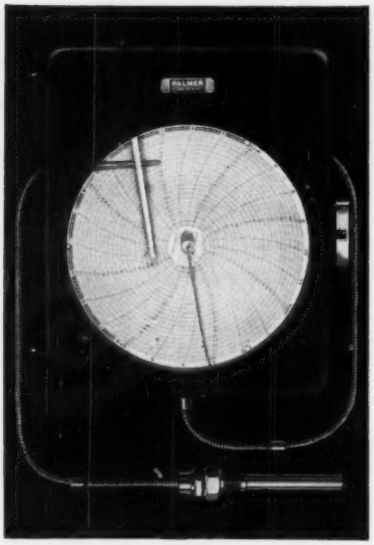

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## *Building . . .*

research center and one of the largest and most fully-equipped research facilities in the Southwest.

The center, which will occupy 35.2 acres of land, will be comprised of 15 separate laboratory and office buildings, six pilot-laboratory bays, service buildings and enclosed storage areas, all set in a campus-style arrangement and connected by covered walkways.

Research activities will encompass the development and manufacture of new petrochemicals, the continued search for better and more economical refining processes, the composition and uses of asphalt, problems in corrosion and contamination, and studies in almost every area of petroleum fuels and lubricants.

New 18-MMcf-per-day Whiting plant will replace a number of older ones.

## Vapor Recovery Unit for Indiana Standard

A new vapor recovery unit that will process 18 MMcf of refinery gases daily has been put into operation by Standard Oil Co. (Indiana) at its Whiting refinery. The new multi-million dollar processing unit will replace a number of older ones having higher operating costs. One new feature of the vapor recovery unit is automatic sampling and recording—by gas chromatography—of products manufactured. Gases processed come from other refining operations, such as catalytic cracking.

In the new equipment there are eight main distillation towers, ranging from 55 feet to 118 feet high. In addition, distinctive twin towers 117 feet high and 12 feet in diameter are used as fuel gas pressure storage vessels. They serve to hold the refinery's fuel gas system at a constant pressure.

The new unit is located on a 2.3-acre site in the central portion of the refinery. It covers an area about 220 feet by 460 feet. Prime contractor for the plant was Arthur G. McKee Co.

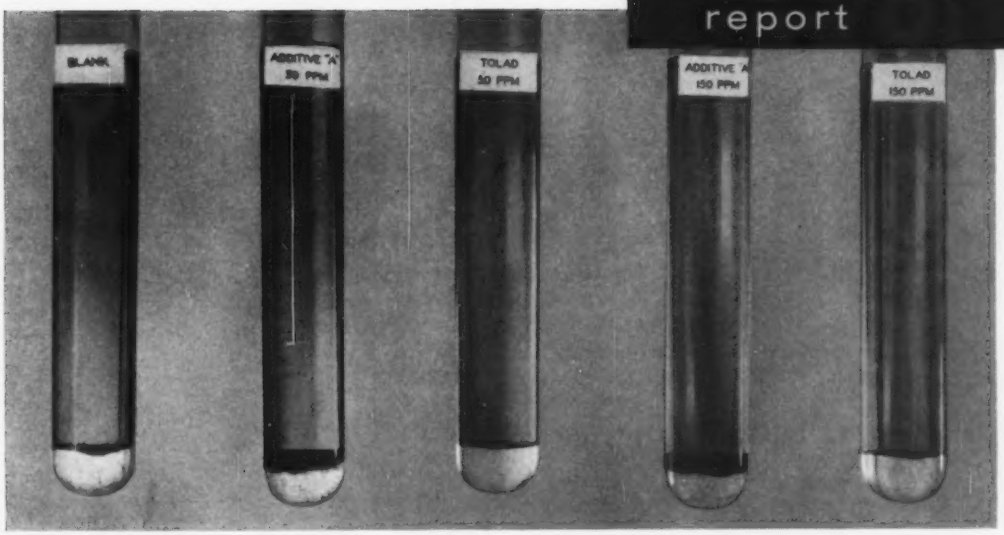
**American Cyanamid Co.** looks for a saving of almost two million btu's per hour at its Bound Brook, N. J., plant with the installation of a new heat exchanger which uses the recuperative principle of heat recovery. It will capture and utilize btu's formerly wasted in the atmosphere. As exhaust gas passes through the unit, metal fins with an exposed surface of almost 6,000 square feet, trap the heat and conduct it through a separating wall into the path of incoming air. The fins extending into the flow passage of cool air preheat the incoming air before its entry into the super-heater.

Cool air is drawn into the system by a compressor, and after passing through the heat exchanger, is fed into the super-heater to support combustion of the fuel oil. Since the incoming fresh air arrives in the super-heater at a temperature of over 700° F—increased by the preheater from 100° F—there is a substantial reduction in fuel requirements.

**The Borden Co. and United States Rubber Co.** have revealed a planned program for construction of a $50-million complex of chemical plants which would convert hydrocarbons into more than a dozen chemical products. The two companies are forming a jointly-owned chemical firm to be called Monochem, Inc. It would erect a major chemical manufacturing unit using hydrocarbons, such as natural gas or low flash point liquid fuel, as a starting point for the production of acetylene and vinyl chloride monomer.

Present plans call for both companies to erect adjacent individually owned plants which will use the output of the Monochem plant for the manufacture of other chemical products. The companies disclosed that they have optioned several industrial sites in Louisiana between Baton Rouge and eastern New Orleans, and in Texas in the Corpus Christi to Houston area. Other locations are under consideration. For some time, site survey

another
# TRETOLITE SERVICE
report

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Compare the quantities of sludge in the test tubes. The TOLAD-treated fuel samples show much less sludge than the samples treated with a well-known competitive additive.

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### WHY IS WATER TOLERANCE IMPORTANT?

When agitated, No. 2 fuel oils and diesel fuels form sludge if they contain water and insoluble residue. Some additives actually impair water tolerance.

### HOW DO FUEL ADDITIVES AFFECT WATER TOLERANCE?

Additives which are primarily dispersants allow insoluble residue to form freely, but disperse it throughout the fuel. However, they also disperse any water which the fuel may contain, thus promoting emulsification, and eventually, sludge formation.

### WHY DO TOLAD ADDITIVES MAINTAIN MAXIMUM WATER TOLERANCE?

TOLAD additives are primarily *inhibitors*. The normal water tolerance of the fuel is not impaired, and the residue problem is corrected by inhibition, rather than dispersion.

The use of TOLAD additives enhances marketability, and practically eliminates burner-tip fouling and filter plugging. In diesel fuel injection systems, TOLAD treatment prevents fouling, increases nozzle life.

*In commercial application,* TOLAD *has provided these advantages at costs under those of the additives it replaced.*

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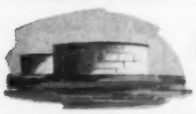

**DIMETCOTE**—a 100% inorganic, zinc silicate coating for severe weather exposure, salt water spray, fresh water, etc.
Typical applications: Offshore rigs, floating roof tanks, steel structures, pipelines, cooling tower piping, etc., and as a permanent primer.

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## *Building . . .*

teams have been making engineering studies of the properties under option.

The Monochem plant, on which construction will start later this year, initially will produce more than 80 million pounds of acetylene and approximately 150 million pounds of vinyl chloride monomer yearly. This would make it one of the largest plants of its type in the country.

### Two New Synthetic Rubbers For Projected Texas Plant

Two new synthetic rubbers will be produced in a new, multi-million dollar plant to be constructed near Beaumont, Texas, by Goodyear Tire & Rubber Co.

The two new man-made rubbers will

be made from isoprene and butadiene. The isoprene rubber has a physical structure which duplicates the natural rubber molecule and can be used both as an extender and a replacement for the natural product. It has exceptionally high flex and heat resistance, it was explained.

The second new synthetic (from butadiene) is an extender for natural rubber and has many applications. Both rubbers will be used in tires, industrial products such as conveyor belts, and in other products. To date, the new rubbers have been produced in limited quantities in pilot plants at Akron. The Beaumont plant will be the company's first production operation engineered for commercial output. Construction is to begin immediately, with production expected in a year. Scientific Design Co. will design and engineer the unit.

**British American Oil Co., Ltd.** has awarded a contract worth approximately $400,000 to The Fluor Corp. of Canada, Ltd., to engineer and construct a 3,500-

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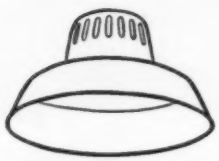

Explosion-proof—Type EV, Dust-ignition-proof—Type DL in slotted dome or angle reflectors.

Vapor-tight, weather resistant types V and VM in slotted dome or angle reflectors.

Reduce fatigue, accidents and worker tension; improve working environments and employee relations. In both original and replacement installations in major plants, the new slotted reflectors—exclusive with Crouse-Hinds—produce the following results:

- Elimination of dark, dungeon-like areas above reflectors
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- Reduction of fatigue of workers, and accidents due to fatigue
- Increase of production in machine work, assembly and inspection operations
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EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12," for steel and C.I. pipe. Stocked by practically all oil supply stores.

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## *Building . . .*

bpd naphtha hydrodesulfurization unit. It will be erected at British American's refinery at Calgary, Alba. The unit will remove sulfur compounds from naphtha by catalytic action. Engineering is under way in Fluor's Los Angeles office. Construction will commence in August and is scheduled for completion in September.

**British Petroleum Canada, Ltd.** has completed its first refinery in North America at Ville d'Anjou, 10 miles east of Montreal, Canada. The new 25,000-bpd plant has been designed to produce a high yield of high octane motor gasoline together with kerosine, diesel oil, furnace oils and heavy fuel oil. Liquefied petroleum gas will also be produced and refinery waste gases sold for petroleum chemical production.

**Delhi-Taylor Oil Co.** has set up an affiliate, Petrolera Delhi Guatamala S. A., to build a 10,000-bpd refinery in Guatamala. The $8.8-million unit would be financed wtih 30 percent Guatamalan capital and 70 percent foreign capital. It would be built at Matias Galvez.

**Allied Chemical Corp.** plans to triple production of isocyanates to 25 million pounds per year at Moundsville, W. Va. The multi-million-dollar project, to be expanded by stages, is to be complete in 1961.

**The Dow Chemical Co.** plans to up anhydrous ammonia capacity at its Freeport, Texas, plant to 115,000 tons per year. The company will also build a new plant at Plaquemine, La., with a 50,000-ton-per-year capacity.

**Ethyl Corp. of Canada, Ltd.** has awarded a contract for phase II field construction of an ethyl chloride-ethylene dichloride plant at Corunna, Ont., to Canadian Badger Co., Ltd. Canadian Badger recently completed a contract for phase I construction covering foundation and underground work. Work has already begun on the plant, which is scheduled for completion in mid-September 1960.

**Shell Chemical Co., Ltd.** is boosting to 50,000 tons per year its polyolefin capacity at Carrington, England. To be completed next year, the project will result in 30,000 tons of polyethylene and polypropylene. Shell's current polyethylene production is about 1,000 tons per year.

**Ruhrchemie A.G.** has completed installation of a Unifining-Platforming unit at Oberhausen-Holten, Germany. Full range platformate from the 2,000-bpd unit is blended with light cracked gasoline from a catalytic cracking unit to produce a 94-95 octane number (F-1 clear) premium gasoline. Platformer feed stock, an Arabian naphtha boiling in the 185°-365° F range, is supplied by the 2900-bpd Unifining unit. In addition to pretreating 2,000 bpd of naphtha for Plat-

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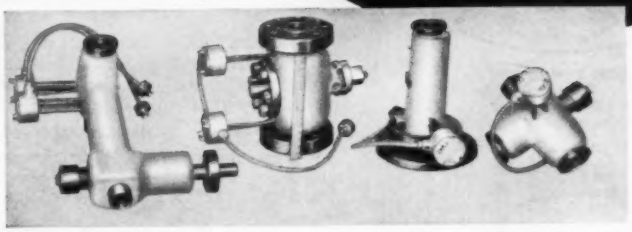

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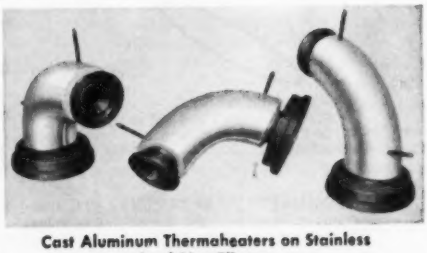

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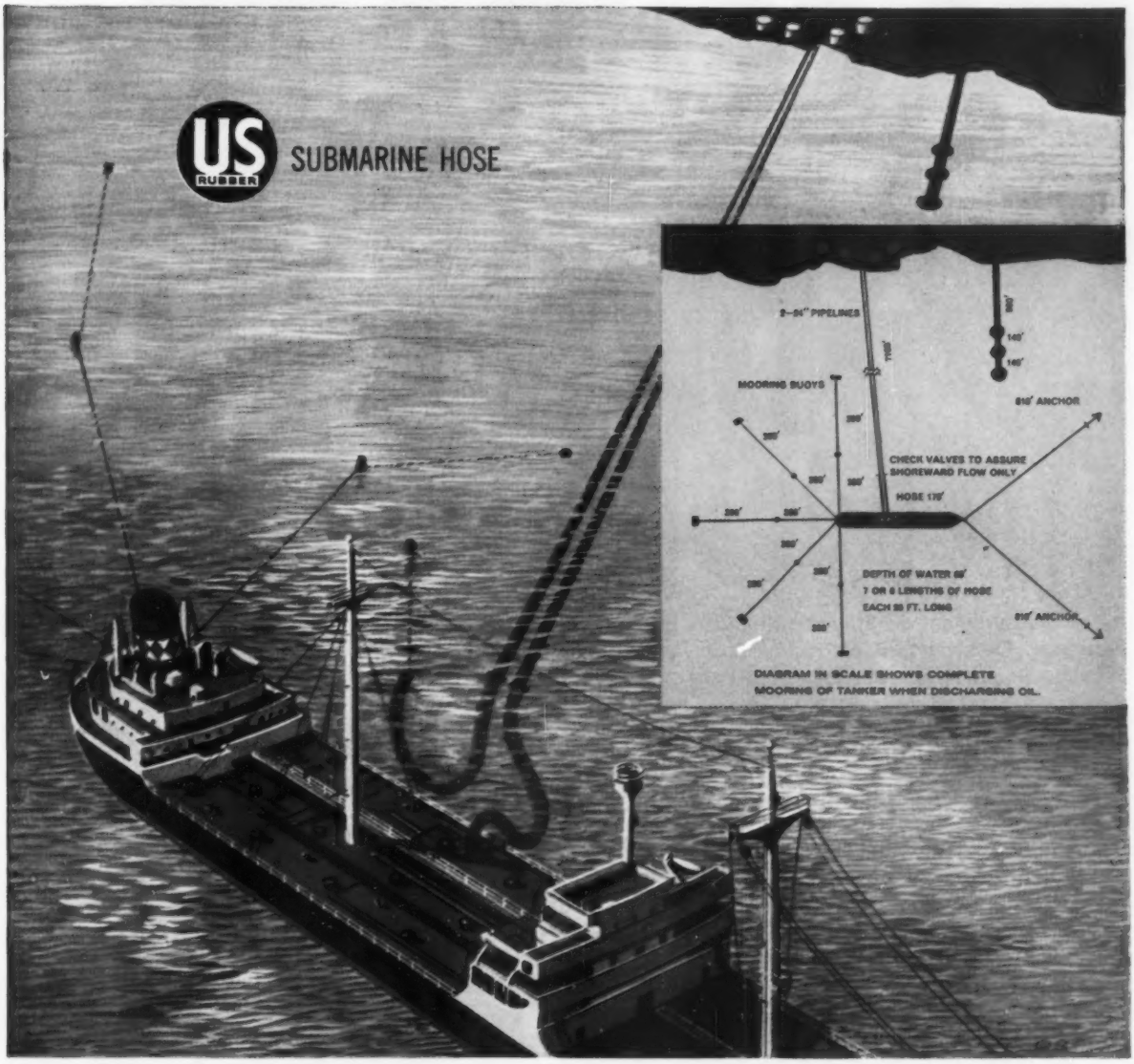
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DIAGRAM IN SCALE SHOWS COMPLETE MOORING OF TANKER WHEN DISCHARGING OIL.

# From tanker to shore...the hook-up is U.S. Amazon Hose

The only submarine unloading point for oil tankers on the East Coast is at the Northville Dock Corp., Long Island, N.Y.

The operators say that submarine unloading would be impossible without hose of this character. Foreign and domestic tankers use this undersea hose (7100 feet offshore) as a hook-up to pipelines discharging heavy and light fuel oil directly into storage tanks on shore. Expensive dock and wharfage facilities are eliminated. *The tankers are moored at sea.*

The U. S. Amazon® Hose H2323 in use here resists the corrosive action of salt water and the turbulent action of swift tides. Its lightness and flexibility enable crew members to make it fast to the deck headers in record time. Also it curves easily from the water to the deck. There is never any sharp bend to impede flow.

Similar installations for other oil companies are located at world-wide points, proving the soundness of the construction features and the over-all quality of U. S. Amazon Hose.

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## Building . . .

former feed, the Unifining unit treats 900 bpd of light gasoline. Hydrogen for the Unifining unit is supplied by the Platformer.

**Sun Oil Co.** plans to build an $8-million plant to produce refined-grade petroleum naphthalene at its Toledo, Ohio, plant. The new unit is scheduled to be in operation around the end of 1961 with a capacity of 100 million pounds per year. It will be the "largest petroleum naphthalene plant in the world," says the company. Naphthalene will be made by a Sun process that upgrades intermediate petroleum products from other refining units. Naphthalene produced at the Sun plant will provide a high-purity material for the increasing number of fluid-bed phthalic anhydride manufacturers. It also will find application in other refined end uses.

**British Petroleum Co.** plans construction of a lubricating oil plant in Kwinana, Western Australia. The plant, to produce about 100,000 tons a year of high quality lubricants for both domestic and export markets, will be adjacent to BP's Kwinana refinery. Construction is expected to start later this year, and the plant should be commissioned in 1963.

**Oronite Chemical Co.** plans to double its polybutene capacity in a $3.4-million expansion. Two existing units will be expanded and a new one built at Richmond, Calif. The company says it will be the world's largest polybutene producer after completion of the expansion.

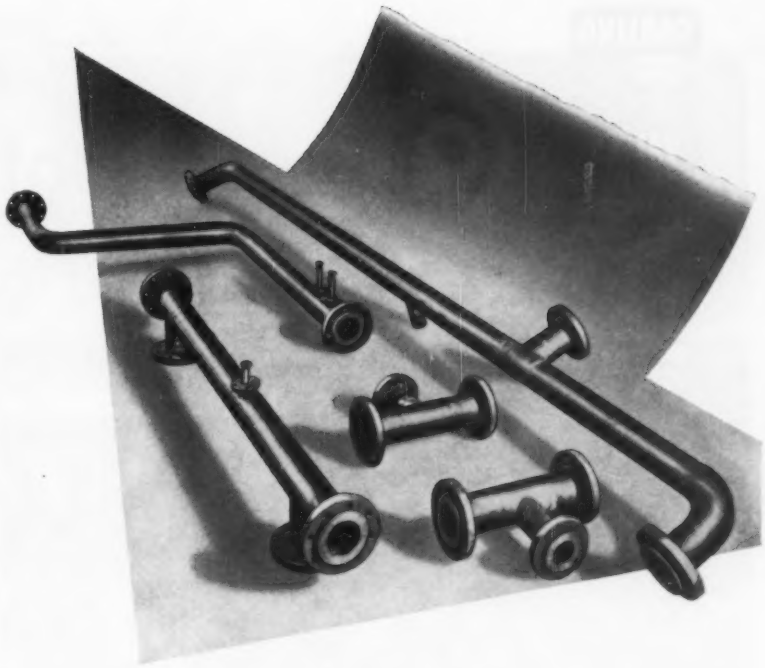
**Industria Raffinazione Oli Minerali SpA.** plans to build a 4,000-bpd catalytic reformer at its Porto Marghera refinery. The unit will be in addition to a 6,000-bpd thermal reformer and a 3,000-bpd catalytic reformer.

**Koppers Co., Inc.** has completed expansion of its Oil City, Pa., alkylated phenol plant. Among the first of the new products of this plant will be paratertiary butyl phenol, para-tertiary amino-phenol, amino-phenol, and dibutyl phenol.

**Cities Service Oil Co.** has started construction of facilities to make several grades of aviation gasoline and jet fuels at its Trafalgar, Ont., refinery. The project will cost about $500,000.

**Colton Chemical Co.** is building a copolymer and polyvinyl acetate plant in Los Angeles County. To be in operation by the end of this year, the project's estimated cost is about $250,000.

**Petro-Tex Chemical Corp.** plans to build a 30-million-pound-per-year maleic anhydride plant at Houston. Scheduled for completion in mid-1961 the plant will use a new process for manufacturing maleic anhydride, using low-cost $C_4$ hydrocarbons as a starting raw material. Developed by Petro-Tex, the new process has been proved in pilot-plant operation.

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Put Ampco Pipe on your tough, liquid-handling jobs, and, mister, you've got something. First of all you've got pipe that's easier and less costly to install. It stands up under wrenches and hammers without thread distortion and subsequent leakage. It is readily welded with shielded arc procedures. "On-the-job" changes and maintenance may be done by the average weldor.

Pipe made from this unique aluminum-bronze alloy is hard, yet it's unusually tough — gives you Brinell hardnesses of 150 and tensiles up to 70,000 psi. It has high strength-to-weight ratios.

But here's the best part of the story. It is highly resistant to many acids and caustics. It has high velocity tolerance—permits flow rates up to 18-20 fps. It withstands the action of abrasive solids in suspension and resists cavitation-pitting. It combines the advantages of many different pipe materials without their drawbacks.

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For more data on advertised products, use Readers' Service Cards, last page.

DARLING VALVES

*Photo courtesy of Freeport Sulphur Co. and Sikorsky Aircraft.*

# 90 DARLING VALVES

## to help tap new sulphur deposit

Above you see part of Freeport Sulphur's $30,000,000 project to tap a major new sulphur deposit. It's the world's first offshore sulphur mining plant at Grand Isle...seven miles off the coast of Louisiana in the Gulf of Mexico.

Valves on the mile-long "steel island" mining plant were supplied by Darling. They include 2" to 12" OS and Y and 6" to 10" check valves made from Ni-Resist with monel trim ...all for use in corrosive service.

Here's another case where Darling's extensive research and development on corrosion-resistant valves helped solve a specialized operating problem. And on gate valves, Darling's *exclusive revolving double disc parallel seat feature* assures positive sealing and ease of operation at all times.

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*Darling OS and Y gate valve with flange ends . . . one of types being supplied for Freeport Sulphur's Grand Isle sulphur mining plant.*

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## *Building . . .*

The high-volume production of four-carbon feedstocks gives the new process the advantage of lower unit cost for its raw materials, according to Petro-Tex. The processes advantage, says the company, is in the straight-forward oxidation of four-carbon feedstock to produce the four-carbon maleic anhydride. This improves on the conventional process based on six-carbon benzene which inherently loses one-third of the feedstock. Engineering is being done by Scientific Design Co., Inc., which has licensed to Petro-Tex certain phases of its maleic anhydride technology.

**Consumer's Co-Operative** will construct two processing units—a 6,000-bpd distillate Unifiner and 3,000-bpd Platformer, at Regina, Sask. Completion of the units, which will be built by Procon (Canada) Ltd., is scheduled for December 1960.

**Danbritkem A/S,** Copenhagen, Denmark, has been formed jointly by Imperial Chemical Industries, Ltd., A/S Dampskibsselskabet Svendborg, and Dampskibsselskabet af 1912 A/S. The latter two firms own Copenhagen's Maersk refinery. The newly organized company plans to build a 15,000-ton-per-year polythene plant adjacent to the Maersk plant.

**Diamond Alkali Co.** plans to invest $30-35 million in the next two years for polyvinyl-chloride resin capacity, polyvinyl monomer facilities and enlargement of organics operations. One project in the planning stage is a plant to produce acetylene by partial oxidation of natural gas.

**Dow Chemical of Canada** plans to construct an ethylene products plant at Fort Saskatchewan, Alta. The new unit will manufacture ethylene oxide, ethylene glycol and ethanolamine from separated LPG or natural gas.

**Egypt** plans to double its current refining capacity to 130,000 bpd by 1963. Added capacity will include 20,000-bpd at the Suez refinery of Anglo-Egyptian Oilfields, a British Petroleum Co.-Shell Oil Co. affiliate.

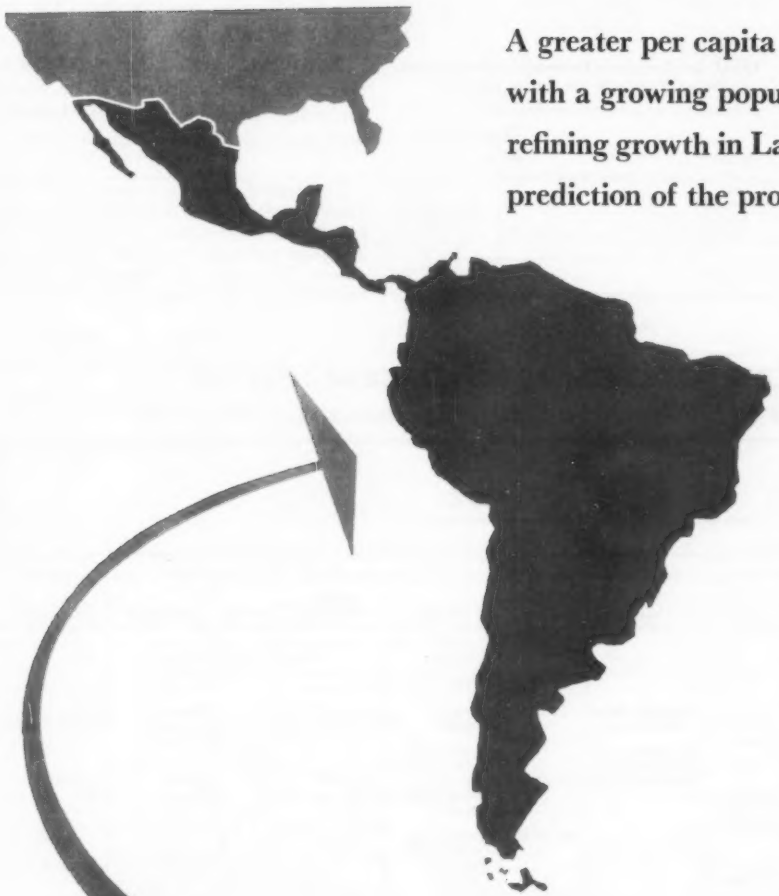
**Esso S. A.** has received customs exemptions in connection with a refinery it plans to build in San Salvador. To be constructed on the Pacific Coast at Acajutla, the refinery is scheduled to be completed within two years.

### ERRATA

**An error appeared in "Construction Boxscore," April 1960 issue, page 261, under Standard Oil of Calif. (West Coast). Stancal is shown as having under construction a refinery at Everett, Wash. This entry should have been under Richfield Oil Corp. Our apologies.**

"Construction Boxscore" reveals . . .

# Need for New Refining Growing in Latin America



**A greater per capita consumption rate combined with a growing population gives impetus to refining growth in Latin America. Here is a prediction of the processes which will be needed.**

REFINING CAPACITY in Latin American countries is expected to increase by more than 50 percent before 1970. At that time the average-size refinery will handle around 48,000 bpd of crude compared with the 38,000-bpd throughput for an average refinery operating at the end of 1959.

**Construction.** Future construction will be required in order to keep up with a growing demand as well as a shift in product distribution. It is estimated that an average refinery will need to spend $20 million for new units before 1970. The shift in capacity for different processing during this period is shown in Table 1.

In terms of additional refining units, processing capacity for 10,000 bpd of crude oil will be required. Other capacity increases will be 13,100 bpd of catalytic cracking (including hydrocracking), 6,500 bpd of catalytic reforming, 6,700 bpd of hydrogen treating, 1,500 bpd of alkylation and 400 bpd of polymerization.

These represent additions to basic refining capacity only and exclude normal replacements. The additions

**TABLE 1—Processes in an Average Latin America Refinery**

| | 1959 | | 1970 | |
|---|---|---|---|---|
| | BPD | % of Crude | BPD | % of Crude |
| Crude Capacity | 38,000 | 100.0 | 48,000 | 100.0 |
| Thermal Cracking | 10,000 | 26.3 | ..... | ..... |
| Catalytic Cracking | 4,900 | 12.9 | 18,000 | 37.5 |
| Thermal Reforming | 1,000 | 2.6 | ..... | ..... |
| Catalytic Reforming | | | 7,500 | 15.6 |
| Hydrogen Treating | 1,300 | 3.4 | 8,000 | 17.0 |
| Alkylation | 300 | 0.8 | 1,800 | 3.8 |
| Polymerization | 240 | 0.6 | 640 | 1.3 |

*Construction Boxscore reveals current activity in the oil, gas and petrochemical processing industry. Here is your chance to compare forecasts and predictions with announced projects*

will be needed to cope with the 1970 demand of Latin American countries for 4.3 million bpd of pertoleum products as compared with the 1.4 million demanded in 1959.

**Population.** Growing population accounts for a big portion of the increased demand. At the end of 1956, the latest recorded figures, the total Latin American population was estimated at just under 190 million. By 1970 the population is expected to reach 267 million, about a 40 percent increase.

In addition to a population growth, the per capita use of motor vehicles is predicted to soar. Motor vehicles in use in 1956 were just under 3.4 million passenger cars and commercial vehicles. A conservative estimate for 1970 places the number at about 9.5 million. This represents a gain of 180 percent in motor vehicles in operation.

**Distribution Shift.** A shift in distribution will be needed to meet the demands of these growing countries. It is very likely that a much greater portion of petroleum products will be shifted to the gasoline and middle distillate range. A breakdown of petroleum products demand in 1959 and the distribution forecast for 1970 are shown in Table 2.

For these forecasts, Latin American countries are considered to be South America, Mexico, Central America and the Caribbean area.

**TABLE 2—Domestic Demands of Petroleum Major Products for Latin America**

| PRODUCTS | Percent of Total | |
|---|---|---|
| | 1959 | 1970 |
| Gasoline | 31.5 | 37.5 |
| Kerosine | 10.0 | 13.5 |
| Distillate Fuels | 18.5 | 25.0 |
| Residual Fuels | 38.7 | 22.5 |
| Lube Oils | 1.3 | 1.5 |
| Total | 100.0 | 100.0 |

**Condensed from a report by S. W. Curry and E. W. Schnabel, Universal Oil Products Company, presented before the joint meeting of AIChE and the Instituto Mexicano de Ingenieros Quimicos, Mexico City, June, 1960.**

# Construction Boxscore

## Oil, Gas and Petrochemical Processing Plants

## East

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Air Products | Allentown, Pa. | *Liquid Helium | | | Complete | | | | |
| | | *Liquid Hydrogen | | | Complete | | | | |
| | Iselin, N.J. | *Liquid Helium | | | Under Constr | | | | |
| Allied Chemical | Moundsville, W. Va. | Fumaric Acid | | | Complete | | | | |
| American Cyanamid | Bridgeville, Pa. | Maleic Anhydride | 20,000,000 lbs/yr | | Complete | | S D | S D | S D |
| | Bound Brook, N.J. | Phthalic Anhydride | 7,000,000 lbs/yr | | Complete | | | | Foster Wheeler |
| Ashland O&R | Buffalo, N.Y. | Naphthalene | 50,000,000 gal/yr | | Under Constr | | UOP | | |
| | | Benzene | 12,000,000 gal/yr | | Under Constr | | UOP | | |
| AviSun | New Castle, Del. | Polypropylene Resin | 100,000,000 lbs/yr | $30,000,000 | Engineering | May 1961 | Staff | Bechtel | Bechtel |
| Cary Chemicals | Flemington, N.J. | Polyvinyl Chloride, Polymers | | | Under Constr | 1960 | SD | SD | SD |
| Du Pont | Belle, W. Va. | Urea, Ammonia, Methyl Methacrylate, Nylon Intermediates | | | Planning | 1961 | Texaco | | |
| | Florence, S.C. | Polyester | | $20,000,000 | Under Constr | 1961 | | | |
| | Memphis, Tenn. | Acrylonitrile | | | Under Constr | | | | |
| | New Jersey | Hydrogen | | | Engineering | | | Chemico | Chemico |
| Esso Standard | Bayway, N.J. | Exp. Cat Cracker Light Ends | | | Complete | | | | |
| | Bayonne, N.J. | Asphalt | | | Complete | | | | |
| Foster Grant | Leominster, Mass. | Plastic Polymers, Copolymers, Styrene Monomer, Molded Plastics | | $4,000,000 | Planning | | | | |
| Frontier Refining | Jacksonville, Fla. | Refinery | 10,000 bbls | | Planning | | | | |
| Grace Chemical Div., W.R. Grace | Memphis | Exp. Ammonia | 450 tons | | Under Constr | Mid 1961 | | | |
| Gulf Oil | Philadelphia | Oxo Alcohols | 35,000,000 lbs/yr | | Under Constr | Dec 1960 | Gulf Oil | Badger Mfg/Gulf | Badger Mfg/Gulf |
| | Charleston, S.C. | Exp. Ethylene | | | Under Constr | Summer 1960 | | | |
| Hercules Powder | Burlington, N.J. | Dimethyl Terphthalate | 36,000,000 lbs/yr | | Under Constr | Oct 1960 | | | |
| Hess Trading & Transport | Sewaren, N.J. | Exp. Refinery | 35,000 bbls | | Planning | | | | |
| | | Udex | | | Planning | | | | |
| | | Catalytic Cracking | | | Planning | | | | |
| Heyden Newport Chemical | Fords, N.J. | Maleic Anhydride | 24,000,000 lbs/yr | | Under Constr | Late 1960 | | S D | S D |
| Kendall Refining | Bradford, Pa. | Crude Revamp | 5,000 bbls | $160,000 | Under Constr | Summer 1960 | | Litwin | Staff |
| Koppers | Follansbee, W. Va. | Desulfurization | 60,000,000 lbs/yr | | Under Constr | Late 1960 | | Staff | Staff |
| | Kobuta, Pa. | *Phthalic Anhydride | | | Under Constr | 1960 | | Foster Wheeler | Foster Wheeler |
| Mobay Chemical | New Martinsville, W. Va. | Exp. Toluene Diisocyanate | 13,000,000 lbs/yr | | Complete | | | | |
| Novamont | Neal, W. Va. | Isotactic Polypropylene, Other Petrochemicals | 22,000,000 lbs/yr | | Under Constr | Early 1961 | Montecatini | Staff | Staff |
| Olin Mathieson | Brandenburg, Ky. | Ethylene Oxide | | | Under Constr | Late 1960 | Shell Devel | Lummus | Lummus |
| Pantasote | Passaic, N.J. | Polyvinyl Chloride | | | Under Constr | 1960 | SD | SD | SD |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Pittsburgh Coke & Chemical | Neville Island, Pa. | Maleic Anhydride | 20,000,000 lbs/yr | ..... | Planning | Early 1961 | ..... | SD | SD |
| Quaker State Oil Refining | Farmers Valley, Pa. | Exp. Refinery | ..... | $400,000 | ..... | ..... | ..... | ..... | ..... |
| Reichhold Chemicals | Elizabeth, N.J. | Maleic Anhydride | 20,000,000 lbs/yr | $4,000,000 | Complete | ..... | Badger Mfg. | Badger Mfg. | Badger Mfg. |
| | Tuscaloosa, Ala. | Formaldehyde | 35,000,000 lbs/yr | ..... | Planning | ..... | Staff | Staff | Staff |
| | | Phenol | ..... | $2,500,000 | Under Constr | ..... | ..... | ..... | ..... |
| Shell Oil | Little Creek, Miss. | Natural Gas Liquids | 6MMcf | ..... | Planning | ..... | ..... | ..... | ..... |
| Standard of Indiana | Whiting, Ind. | *Vapor Recovery | ..... | ..... | Under Constr | 1960 | ..... | McKee | McKee |
| | | *Exp. Cat Cracker | 10,000 bbls | ..... | Engineering | June 1960 | ..... | Kellogg | Staff |
| | | *Alkylation | 11,400 bbls | ..... | Engineering | 1961 | ..... | Bechtel | Bechtel |
| Stauffer Chemical | La Moyne, Ala. | Methane Purification | ..... | ..... | Complete | ..... | ..... | Treco | Treco |
| | Delaware City, Del. | Carbon Bisulfide | ..... | ..... | Under Constr | Nov 1960 | ..... | Staff | |
| Sun Oil | Marcus Hook | Propylene Fractionating | 60,000,000 lbs/yr | $1,965,000 | Complete | ..... | ..... | Staff | Staff, others |
| | | Exp & Modernize Grease Plant | ..... | $450,000 | Complete | ..... | ..... | Staff | Staff |
| | | Exp. Wax Moulding and Packaging | ..... | $637,000 | Complete | ..... | ..... | Staff | Staff |
| | | Automatic Tank Gauging | ..... | $428,000 | Complete | ..... | ..... | Staff | Staff |
| | | Chassis Dynamometer Addition | ..... | $352,000 | Complete | ..... | ..... | Staff | Staff, others |
| | | Automatic Crude Blending | ..... | $230,000 | Complete | ..... | ..... | Staff | Staff |
| | | *Product Control Center | ..... | $150,000 | Complete | ..... | ..... | Staff | Staff |
| | McComb, Miss. | *Natural Gasoline | 10 MMcf | $1,400,000 | Engineering | Fall 1960 | ..... | Pona | Pona |
| SunOlin Chemical | North Claymont, Del. | Exp. Ethylene, Ethylene Oxide, Ethylene Glycol | 200,000 lbs/yr | $15,000,000 | Engineering | ..... | ..... | ..... | ..... |
| | | *Urea | 200 tons | $8,000,000 | Complete | ..... | ..... | Kellogg | Kellogg |
| Tennessee Corp. | East Tampa, Florida | *Ammonia | 100,000 tons/yr. | $13,000,000 | Planning | Early 1962 | ..... | ..... | ..... |
| Tennessee Eastman | Kingsport, Tenn. | High-Purity Hydrogen | 900 Mcf | ..... | Complete | ..... | ..... | Girdler | Girdler |
| United Refining | Warren, Pa. | *$H_2SO_4$ Alkylation | 1,100 bbls. | $1,300,000 | Under Constr | Late 1960 | ..... | Kellogg | Kellogg |

## Mid-Continent

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Allied Chemical | South Point, Ohio | *Exp. Methanol | 50% | ..... | ..... | ..... | ..... | ..... | ..... |
| | | *Exp. Formaldehyde | 35% | ..... | ..... | ..... | ..... | ..... | ..... |
| Ashland O & R | Canton, Ohio | Gas Revamp | ..... | ..... | Planning | Dec 1960 | ..... | ..... | ..... |
| Aurora Gasoline | Detroit | Vacuum Distl. | 18,000 bbls | ..... | Complete | ..... | ..... | Treco | Treco |
| | | Naphtha Unifining | 8,000 bbls | ..... | Under Constr | 1960 | UOP | UOP | Treco |
| Borden Chemical | Illiopolis, Ill. | Polyvinyl Chloride | 40,000 000 lbs/yr | $4,000,000 | Planning | ..... | ..... | ..... | ..... |
| British American | Oklahoma | *Natural Gasoline | 50 MMcf | ..... | Under Constr | Mid 1960 | ..... | Olsen | Olsen |
| Century Refining | Garden City, Kan. | Catalytic Cracking | 3,000 bbls | ..... | Complete | ..... | Socony | Litwin | Litwin |
| | | Gas Concentration | ..... | ..... | Complete | ..... | ..... | Litwin | Litwin |
| | | $C_3$-$C_4$ HF Alkylation | 800 bbls | ..... | Complete | ..... | Phillips | Litwin | Litwin |
| Champlin Oil & Refining | Enid, Okla. | *Exp. Cat Cracker | 20,000 bbls. | ..... | Under Constr | 1960 | Kellogg | Staff/Kellogg | Staff |
| | | *Exp. Alkylation | 2,000 bbls. | ..... | Under Constr | 1960 | Kellogg | Staff/Kellogg | Staff |
| Cimarron Trans. | Love Co., Okla. | *Gas Treating | 40 MMcf | $300,000 | Complete | ..... | ..... | Pona Engineers | Pona |
| Continental Oil | Ponca City, Oklahoma | *Cyclohexane | 20,000,000 gal/yr | $1,000,000 | Under Constr | Sept. 1960 | ..... | ..... | Procon |
| Champlin Oil & Ref. | Enid, Okla. | *Delayed Coker | 5,000 bbls. | ..... | Engineering | 1961 | ..... | Fluor | ..... |
| Cooperative Farm Chemicals | Lawrence, Kan. | Ammonia | 100 tons | $5,400,000 | Under Constr | 1960 | ..... | Chemico | Chemico |
| | | Urea | 30 tons | | | | | | |
| Dow Chemical | Midland, Mich. | Exp. Styrene Monomer | ..... | ..... | Planning | Late 1960 | ..... | ..... | ..... |
| Du Pont | Circleville, Ohio | Polyester | ..... | ..... | Complete | ..... | ..... | ..... | ..... |
| DX Sunray | Duncan, Okla. | *Cat Cracker Revamp | ..... | $600,000 | Complete | ..... | ..... | ..... | Procon |
| Goodyear Tire & Rubber | Akron, Ohio | Exp. Extruded Polyvinyl Chloride | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| Great Northern Oil | Pine Bend, Minn. | Sulfuric Acid Alklation | 2,000 bbls | ..... | Under Constr | Fall 1960 | UOP | Treco | Treco |
| Gulf Oil | Cleves, Ohio | Distillate Treater | 11,000 bbls | ..... | Under Constr | 1960 | UOP | McKee | McKee |
| | Toledo, Ohio | Distillate Treater | 16,000 bbls | ..... | Under Constr | 1960 | Petrico | Staff/Kaighin-Hughes | Staff/Kaighin-Hughes |
| | | Crude and FCCU Revamp | ..... | ..... | Under Constr | 1960 | Gulf/Kellogg | ..... | Kaighin-Hughes/Kellogg |
| Kerr-McGee | Wynnewood, Okla. | FCCU Revamp, TEL Blending | ..... | ..... | Complete | ..... | ..... | Litwin | Kaighin-Hughes/Litwin |
| Lion Oil, Division of Monsanto | El Dorado, Ark. | Unifiner—Platformer | 5,000 bbls | ..... | Engineering | ..... | UOP | UOP/Procon | Procon |
| | | Sulfur Recovery | 15 tons | ..... | Complete | ..... | ..... | Staff | Staff |
| Midland Cooperatives | Cushing, Okla. | *$C_3C_4$ HF Alkylation | 1,300 bbls. | $1,200,000 | Complete | ..... | ..... | B & R | B & R |
| Monsanto Chemical | Monsanto, Ill. | Exp. Phenol | ..... | ..... | Under Constr | Mid 1961 | ..... | ..... | ..... |
| | El Dorado, Ark. | Urea Distl. | ..... | ..... | Under Constr | ..... | ..... | Chemico | Chemico |
| | St. Louis | Exp. Maleic Anhydride | 20,000,000 lbs/yr | ..... | Under Constr | ..... | ..... | SD | SD |
| National Cooperative Refining | McPherson, Kan. | Naphtha Unifiner | 8,000 bbls | $800,000 | Complete | ..... | UOP | Staff/UOP | Treco |
| Northwestern Ref. | St. Paul Park, Minn. | Cat Reformer | ..... | ..... | Planning | 1960 | ..... | ..... | ..... |
| Ohio Oil | Pulaski, Mich. | Natural Gasoline | 25 MMcf | ..... | Under Constr | Mid 1960 | ..... | ..... | ..... |
| RJ Oil & Refining | Princeton, Ind. | Unifiner | 1,700 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| | | Crude Distl. | 5,000 bbls | ..... | Under Constr | 1960 | ..... | ..... | ..... |
| | | Platformer | 1,700 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| Shell Oil | Wood River, Ill. | Catalytic Reformer & Offsite Facilities | 25,000 bbls | $15,000,000 | Under Constr | Aug 1960 | ..... | McKee/Parsons | McKee/Parsons |
| | Healdton, Okla. | Exp. Plant | ..... | $315,000 | Under Constr | ..... | ..... | Staff | Hudson |
| St. Paul Ammonia Products | Pinex Bend, Minn. | Compressor, Auxilliary Facil | 35 tons | $500,000 | Complete | ..... | ..... | Tolts, King Duvall & Asso | Quamco |
| Standard-Indiana | Whiting, Ind. | Vapor Recovery | ..... | ..... | Under Constr | 1960 | ..... | McKee | McKee |
| | | Exp. Cat Cracker | 10,000 bbls | ..... | Engineering | 1960 | ..... | Kellogg | Staff |
| | | Alkylation | 11,400 bbls | ..... | Engineering | 1961 | ..... | Bechtel | Bechtel |
| Standard of Indiana | Wood River, Ill. | *Polybutene | ..... | ..... | Engineering | 1960 | ..... | Procon | Procon |
| | Neodesha, Kans. | *Exp. Crude | 7,500 bbls. | ..... | Under Constr | 1960 | ..... | Staff | Staff |
| Standard-Ohio | Lima, Ohio | Acrylonitrile | ..... | ..... | Under Constr | 1960 | ..... | Badger Mfg | Badger Mfg |
| | | *CO Bioler | ..... | $1,500,000 | Under Constr | Dec. 1960 | Babcock & Wilcox | | |
| Sun Oil | Toledo | Automatic Tank Gauging | ..... | $200,000 | Complete | ..... | ..... | Staff | Staff |
| | | *Propane Deasphalting | 10,500 bbls. | ..... | Under Constr | ..... | ..... | Foster Wheeler | Foster Wheeler |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **Sunray Mid-Continent** | Purcell, Okla. | Exp. Natural Gasoline | 25 MMcf | $600,000 | Under Constr | ..... | ..... | Staff/Tuloma | ..... |
| DX Sunray | Tulsa | *MEK, Solvent Dewaxing & Deoiling | 5,835 bbls. | $7,500,000 | Under Constr | Sept. 1960 | Texaco | Foster Wheeler | Foster Wheeler |
| | | *Benzene Udex | 600 bbls. | $1,500,000 | Under Constr | Oct. 1960 | UOP | Treco | Treco |
| | | *Crude | 85,000 bbls. | ..... | Planning | Summer 1961 | ..... | ..... | ..... |
| | | *Propane Deasphalting | 6,000 bbls. | ..... | Under Constr | ..... | ..... | Foster Wheeler | Foster Wheeler |
| **Union Carbide** | **Marietta, Ohio** | Bisphenol-A | 25,000,000 lbs/yr | ..... | Under Constr | Early 1961 | ..... | ..... | ..... |
| | **Whiting, Ind.** | **Low-density Polyethylene** | **72,000,000 lbs/yr** | ..... | **Under Constr** | 1960 | ..... | ..... | ..... |
| U.S. Rubber | Painesville, Ohio | Exp. Vinyl Resins | to 65,000,000 lbs/yr | ..... | Complete | ..... | ..... | ..... | ..... |
| **Vickers** | **Potwin, Kan.** | **Water Disposal** | ..... | **$200,000** | **Under Constr** | 1960 | ..... | Wilson | **Sherwood/ Litwin** |
| Warren Petroleum | Fashing Field, Okla. | *Gas Processing | 75,000 gals | $2,500,000 | ..... | ..... | ..... | Delta Eng. | Delta Eng. |
| | | *Sulfur | 50 tons | ..... | ..... | ..... | ..... | Delta Eng. | Delta Eng. |
| Western Petrochemicals | Chanute, Kan. | **Waste Disposal** | ..... | ..... | Engineering | 1960 | ..... | Litwin | Litwin |
| | | **Vacuum Distl.** | **500 bbls** | ..... | Engineering | 1960 | ..... | Litwin | Litwin |
| | | **Propane Deasphalting** | **350 bbls** | ..... | Engineering | 1960 | ..... | Litwin | Litwin |

## Southwest

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Allied Chemical | Orange, Texas | Polyethylene Glycol | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| Amarillo Oil/Texaco | Pampa, Texas | Natural Gasoline | 60 MMcf | ..... | Complete | ..... | ..... | Dresser | Dresser |
| **American Oil** | **Texas City** | **Relocated Delayed Coker** | **430 tons** | ..... | Complete | ..... | ..... | **Tellepsen** | **Tellepsen** |
| | | *Crude | 150,000 bbls. | ..... | Under Constr | Fall 1961 | ..... | Kellogg | Kellogg |
| | | *Cat Cracker | 47,600 bbls | ..... | Under Constr | Fall 1961 | ..... | Kellogg | Kellogg |
| | | *Alkylation | 14,600 bbls | ..... | Planning | Fall 1961 | ..... | ..... | ..... |
| | | *Butane splitting, Isomerization | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| **Bay Petroleum** | Chalmette, La. | **Alkylation** | **2,700 bbls** | ..... | Complete | ..... | UOP | **Bechtel** | **Bechtel** |
| | | **Exp Cat Cracker** | **15,000 bbls** | ..... | Complete | ..... | UOP | **UOP** | **Procon** |
| | | **Crude** | **35,000 bbls** | ..... | Complete | ..... | ..... | **Bechtel** | **Bechtel** |
| | Rockport, Tex | *Exp. Gasoline | 75 MMcf | ..... | Under Constr | Late 1960 | ..... | Olsen | Olsen |
| **Carbide & Carbon** | **Seadrift, Texas** | **Exp. Ethylene Oxide** | **To 200,000,000 lbs/yr** | ..... | **Planning** | ..... | ..... | ..... | ..... |
| Carwin | Houston | Special Isocyanates | 500,000 lbs/yr | $1,500,000 | Engineering | Late 1960 | ..... | Pona Engineers | Pona Constructors |
| | Texas City | Exp. Polyethylene | ..... | ..... | Engineering | ..... | ..... | B&R | ..... |
| | | Exp. Ethylene Glycol | 65 MMcf | ..... | Planning | ..... | ..... | ..... | ..... |
| Coastal Products | Corpus Christi, Texas | Delayed Coking | 7,000 bbls | $3,000,000 | Under Constr | ..... | ..... | Treco | Treco |
| Continental Carbon | Westlake, La. | *Exp. Carbon Black | to 70,000,000 lbs/yr | ..... | Complete | ..... | ..... | ..... | ..... |
| Continental Oil | Lake Charles, La. | Straight-Chain Primary Alcohols | 50,000,000 lbs/yr | ..... | Under Constr | Early 1961 | ..... | ..... | ..... |
| | | Cat Reformer | 11,000 bbls | $3,000,000 | Under Constr | ..... | ..... | Bechtel | Bechtel |
| | | *Exp. Natural Gasoline | to 150 MMcf | ..... | Under Constr | Jan 1961 | ..... | Hudson | Hudson |
| | Reeves County, Texas | Natural Gasoline | 65,000 gals | ..... | Complete | ..... | ..... | Russell Engineering | Russell Engineering |
| Copolymer Rubber & Chem. | Baton Rouge, La. | *Rubber | to 118,000,000 lbs/yr | $3,000,000 | Under Constr | Nov 1960 | ..... | Staff | Staff |
| | | *Butadiene | to 55,000 tons/yr | $5,000,000 | Engineering | Sept 1961 | Dow | Foster Wheeler | Foster Wheeler |
| **Cosden Petroleum** | Big Spring, Texas | Exp. Styrene | to 60,000,000 lbs/yr | ..... | Engineering | ..... | UOP | Badger Mfg | Badger Mfg |
| | | Desulfurization | 6 MMcf | $200,000 | Engineering | August 1960 | ..... | Graff | Badger Mfg |
| | | Ortho-Xylene | 70,000,000 lbs/yr | ..... | ..... | Early 1961 | ..... | ..... | ..... |
| **CM&M Gas Products** | **Wise County, Texas** | **Exp. Gas Processing, Liquid Recovery** | **150 MMcf** | **$700,000** | **Under Constr** | **1960** | ..... | ..... | ..... |
| Delhi-Taylor | Corpus Christi, Texas | Ortho-Xylene Fractionation | 3,000,000 gals/yr | ..... | Complete | ..... | ..... | Staff/UOP | Staff |
| **Dow Chemical** | **Freeport, Texas** | **Acrylonitrile** | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | | Styrene-Butadiene Latexes | ..... | ..... | Engineering | 1961 | ..... | ..... | ..... |
| | | Anhydrous Ammonia | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| | | Exp. Ethylene 67% | ..... | ..... | Engineering | 1961 | ..... | ..... | ..... |
| | | Exp. Styrene Monomer | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | Plaquemine, La. | Polyethylene | ..... | $12,000,000 | Under Constr | Late 1960 | ICI | ..... | ..... |
| | | Vinylidene Chloride | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Methyl Chloriform | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| **Du Pont** | **Orange** | **Polyethylene** | ..... | ..... | **Under Constr** | ..... | ..... | ..... | ..... |
| | **Beaumont** | **Caprolactam** | **50,000,000 lbs/yr** | ..... | **Planning** | **Late 1960** | ..... | **Staff** | **Staff** |
| | | Acrylonitrile | ..... | ..... | Under Constr | Spring 1961 | Staff | Staff | Staff |
| Eastern States Petroleum & Chem. | Houston | Exp. Refinery | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| El Paso Natural Gas | Terrell County, Texas | Treating | 220 MMcf | $4,827,000 | Under Constr | Dec 1960 | ..... | Fluor | ..... |
| | Pecos County, Texas | *Gas Treating | 50 MMcf | ..... | Planning | ..... | ..... | ..... | ..... |
| El Paso Natural Gas Products | Odessa, Texas | Exp. Styrene | to 60,000,000 lbs/yr | ..... | Complete | ..... | ..... | Staff | Staff |
| Esso Standard | Baton Rouge, La. | Exp. Butyl Rubber, Stage I | 20,000 tons/yr | $8,000,000 | Complete | ..... | ..... | ..... | ..... |
| | | Exp. Butyl Rubber, Stage II | 18,000 tons/yr | $8,000,000 | Under Constr | Mid 1961 | ..... | ..... | ..... |
| Ethyl | Houston | Vinyl Chloride Monomer | ..... | ..... | Under Constr | Early 1961 | ..... | ..... | ..... |
| **Firestone** | **Orange, Texas** | **Polyisoprene, Polybutadiene** | **30,000 tons/yr** | ..... | **Engineering** | ..... | ..... | ..... | ..... |
| Goliad/Union Oil of Cal. | Vermillion Parish, La. | Natural Gasoline | 450 MMcf | $4,000,000 | Under Constr | Summer 1960 | ..... | Fluor | Fluor |
| Goodrich Gulf Chemicals | Port Neches, Texas | Polyolefins, High-Density Polyethylene | 13,000,000 lbs/yr | ..... | Under Constr | Late 1960 | Ziegler | Parsons | Parsons |
| Goodyear | Gulf Coast | *Polyisoprene, Isoprene, Polybutadiene | ..... | ..... | Engineering | Jan 1962 | ..... | ..... | ..... |
| **Gulf Oil** | Port Arthur | **Deisobutaniser** | **10,000 bbls** | ..... | **Under Constr** | **1960** | ..... | **Treco** | **Treco** |
| | | **High Purity Ethylene** | **1,400,000 lbs** | ..... | Under Constr | **Summer 1960** | ..... | **Kellogg/Gulf** | **Kellogg/Gulf** |
| | | **Oxo Preparation** | ..... | ..... | Under Constr | **1960** | ..... | Staff/Treco | Treco |
| Hercules Powder | Lake Charles, La. | Polypropylene | 100,000,000 lbs/yr | ..... | Under Constr | 1961 | Staff | ..... | ..... |
| Houston Chemical | Beaumont, Texas | Ethylene Glycol | 8–12,000,000 gals/yr | $12,000,000 | Engineering | 1961 | ..... | ..... | ..... |
| J.M. Huber | Baytown, Tex. | *Furnace Blacks | 170,000 lbs | ..... | Under Constr | Late 1960 | ..... | Staff | B & R |
| **Humble** | **Baytown, Texas** | **Polyolefin** | **40,000,000** | ..... | Complete | ..... | Esso | **Esso** | **Staff** |
| | | Exp Lube Hydrofiner, Dewaxing, Extraction | 6,500 bbls | ..... | Under Constr | **Late 1960** | ..... | Fluor | Staff |
| | **Kleberg County, Texas** | **Gas Process & Cycling** | **800 MMcf** | ..... | **Under Constr** | **1960** | ..... | Hudson | Hudson |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Hunt Oil | Alta Loma, Texas | Natural Gasoline | ..... | ..... | Planning | ..... | ..... | Hudson | Hudson |
| Jefferson Chemical | Conroe, Texas | Morpholine, Polyurethane Resin Intermediates, Speciality Surface-Active Agents | ..... | ..... | Under Constr | Mid 1960 | ..... | ..... | ..... |
| | Port Neches, Texas | *Processing | ..... | ..... | Under Constr | ..... | ..... | Foster Wheeler | ..... |
| Jefferson Lake Sulfur | Greens Bayou, Texas | Exp. Distillation | ..... | $180,000 | Complete | ..... | ..... | Hedrick/B & R | B & R |
| | | Storage | ..... | $70,000 | Complete | ..... | ..... | Merichem | Baker Tank |
| Koppers | Port Arthur | Exp. Polyethylene | ..... | ..... | Under Constr | 1960 | Staff | Staff | Staff |
| La Gloria Oil & Gas | Arcadia Parish, La. | LPG | 176 MMcf | ..... | Complete | ..... | ..... | B & R | B & R |
| | | Natural Gasoline | | | | | | | |
| Mobil Oil | Beaumont, Texas | Exp. Catalytic Reforming | 20,000 bbls | ..... | Under Constr | 1960 | ..... | Fluor | Fluor |
| | | Ethylene | 380,000,000 lbs/yr | ..... | Under Constr | 1961 | ..... | Kellogg | Kellogg |
| | | Exp. Polyethylene | 12,500 bbls | $2,500,000 | Planning | ..... | ..... | ..... | ..... |
| Monsanto Chemical | Gulf Coast | Styrene Monomer | 200,000,000 lbs/yr | $30,000,000 | Planning | Early 1961 | ..... | ..... | ..... |
| Northern Natural Gas | Spearman, Texas | Exp. Natural Gasoline | to 200 MMcf | ..... | Complete | ..... | ..... | Dresser | Dresser |
| Pan American Pet. | North Cowden, Texas | Exp. Gas Compression | ..... | ..... | Under Constr | 1960 | ..... | Staff | B & R |
| | Old Ocean, Texas | Exp. Refinery | ..... | ..... | Engineering | Late 1960 | ..... | B & R | B & R |
| Petroleum Chemicals | Lake Charles, La. | Exp. Ethylene | 100,000,000 lbs/yr | ..... | Under Constr | ..... | ..... | Lummus | ..... |
| Phillips Chemical | Borger, Texas | *Ammonia | ..... | ..... | Under Constr | ..... | ..... | Foster Wheeler | Foster Wheeler |
| | | Multi-Purpose Chemicals | ..... | ..... | Complete | ..... | ..... | Staff | Staff |
| | | Exp. Synthetic Rubber | 20,000 tons/yr | ..... | Under Constr | August 1960 | ..... | ..... | ..... |
| | | Cis-4 Polybutadiene | 20,580 tons/yr | ..... | Under Constr | 1960 | ..... | Staff | Staff |
| | Orange, Texas | *Carbon Black | 60,000,000 lbs/yr | ..... | Under Constr | 1960 | ..... | Staff | Staff |
| | Sweeny, Texas | *Ethylene | | ..... | Engineering | Mid 1961 | ..... | Braun | Braun |
| Phillips Petroleum | Sweeny, Texas | Hexane Isomerization | 1,000 bbls | ..... | Complete | ..... | ..... | Staff | Staff |
| | Borger | Heavy Oil Cat Cracking | 25,000 bbls | ..... | Under Constr | Early 1961 | ..... | Kellogg | Kellogg |
| | | *Natural Gas Liquids | ..... | ..... | Under Constr | Late 1960 | ..... | ..... | Staff |
| Runnels Gas Products/Texas Gas Exploration | Eunice, La. | Exp. Extraction | to 800 MMcf | ..... | Planning | Jan 1961 | ..... | Fluor | Fluor |
| Shell Oil | Deer Park, Texas | Distillate Hydrotreater & Offsite Facilities | 30,000 bbls | $3,500,000 | Complete | ..... | ..... | Fluor | Fluor |
| | Norco, La. | Asphalt Blender, Storage Tanks, Steam Generator | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| | Sheridan, Texas | Gas Cycling | 150 MMcf | $1,000,000 | Planning | Late 1960 | ..... | ..... | ..... |
| Shell Chemical | Norco, La. | Acrolein | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| | | Glycerine | ..... | $4,500,000 | Under Constr | 1960 | ..... | Staff | Parsons/Fluor |
| Sinclair-Koppers | Houston | Styrene Monomer | 70,000,000 lbs/yr | ..... | Under Constr | Mid 1961 | ..... | ..... | ..... |
| | | *Refinery | 60,000 bbls | ..... | Engineering | Mid 1961 | ..... | Braun | Braun |
| | | *Lube Oil | ..... | ..... | Under Constr | Early 1961 | ..... | ..... | ..... |
| | | *Exp. Refinery | ..... | ..... | Engineering | Late 1961 | ..... | Braun | Braun |
| South Louisiana Production | Jeanerette, La. | Butane, Propane, Other LPG | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| Spencer Chemical | Orange, Texas | Exp. Polyethylene | 120–135,000,000 lbs/yr | ..... | Under Constr | Summer 1960 | ..... | Staff | Quaker Valley |
| Sunray Mid-Continent | Bossier Parrish, La. | Exp Recovery Facilities | 500 MMcf | $500,000 | Planning | Sept 1960 | ..... | ..... | ..... |
| Texaco | Pampa, Texas | *Gasoline | 60 MMcf | ..... | Complete | ..... | ..... | Dresser | Dresser |
| | Paradise, La. | *Exp. Plant | ..... | ..... | Engineering | 1960 | ..... | Olsen | ..... |
| Texas Eastman | Longview, Texas | Polypropylene | 20,000,000 lbs/yr | ..... | Complete | ..... | ..... | Staff | Hudson |
| Texas Alkyls | Houston | Detergents | ..... | ..... | Under Constr | Late 1960 | ..... | Staff | B & R |
| | | Ethyl Aluminum Sesquichloride, Diethyl Aluminum Chloride, other Aluminum Hydrides, Higher Aluminum Trialkyls | ..... | ..... | Planning | 1961 | ..... | ..... | ..... |
| Texas Natural Gasoline | Arcadia, Parish, La. | Natural Gas Liquids | ..... | ..... | Complete | ..... | ..... | Fluor | Fluor |
| Texas-U.S. Chemical | Port Neches, Texas | Exp. Carbon Black-Synthetic Rubber 10% | to 156,000 tons/yr | ..... | Under Constr | Late 1960-Early 1961 | ..... | Tellepsen Petro-Chem Constructors | ..... |
| Tidewater Oil | Franklin County Texas | Cycling | 50 MMcf | ..... | Complete | ..... | ..... | B & R | B & R |
| | | Natural Gasoline | | | | | | | |
| | | Sulfur Recovery | 250 tons | ..... | Complete | ..... | ..... | B & R | B & R |
| | Houma, La. | Natural Gasoline | 75 MMcf | $1,500,000 | Under Constr | Late 1960 | ..... | Olsen | Olsen |
| Transcontinental Gas Pipe Line | Tilden, Texas | *Sulfur Recovery | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| Union Carbide | Seadrift, Texas | Ester & Alcohol | 100,000,000 lbs/yr | ..... | Engineering | 1960 | ..... | ..... | ..... |
| | | Exp. Petrochemicals | ..... | ..... | Under Constr | 1960 | ..... | Staff | B & R |
| | Brownsville, Texas | Chemical Solvents, Intermediates | ..... | $2,500,000 | Under Constr | March 1961 | ..... | ..... | B & R |
| United Carbon | Houston | *Polymer Development Lab. | ..... | $2,500,000 | Planning | ..... | ..... | ..... | ..... |
| U.S. Industrial Chemicals | Houston | Exp. Polyethylene | 100,000,000 lbs/yr | ..... | Complete | ..... | ICI | Kellogg | Kellogg |
| Valera Oil | Tye, Texas | *Natural Gas Liquids | 5 MMcf | ..... | Under Constr | Sept 1960 | ..... | Portable Gasoline Plants | Portable Gasoline Plants |
| Warren Petroleum | Fashing, Texas | Sulfur Recovery | 50 long tons | $500,000 | Complete | ..... | ..... | Graff Engineering | Delta Engineering |
| Western Nat. Gas | Brownsville, Texas | Refinery Revamp | 3,500 bbls | ..... | Under Constr | ..... | ..... | ..... | Staff |
| | | Exp. Refinery | 12,500 bbs | $2,500,000 | Planning | ..... | ..... | ..... | ..... |
| | Edinburg, Texas | Gas Processing | 60 MMcf | ..... | Complete | ..... | ..... | Tuloma Builders | Tuloma Builders |
| | Nursery, Texas | Gas Processing | 10 MMcf | ..... | Complete | ..... | ..... | ..... | ..... |
| Wickett Refining | Wickett, Texas | Platformer | 1,500 bbls | $350,000 | Planning | Nov 1960 | UOP | J C Hinds | J C Hinds |

## Rocky Mountain

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| American Gilsonite | Grand Junction, Colo. | Exp. Coking | 1,100 tons | ..... | Planning | ..... | ..... | ..... | ..... |
| El Paso Natural Gas | Jal, N.M. | Exp. Natural Gasoline | 210 MMcf | $1,266,000 | Complete | ..... | ..... | Dresser | Dresser |
| Farmers Union Central Exchange | Laurel, Mont. | Unifiner | to 7,100 bbls | ..... | Complete | ..... | ..... | ..... | ..... |
| Husky Oil | Cody, Wyo. | Refinery | 9,000 bbls | ..... | Under Constr | ..... | ..... | ..... | ..... |
| Kerr-McGee | Shiprock, N.M. | *Vanadium Extraction | ..... | ..... | Complete | ..... | Staff | Jacobs Eng | Jacobs Eng |

* First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Pan American Petroleum/Hondo Oil & Gas | Eddy County, N.M. | Natural Gasoline, Sulfur Recovery | 15 MMcf | ..... | Complete | ..... | ..... | Olsen | Olsen |
| Phillips | Artesia, N.M. | *Natural Gasoline | 20 MMcf | ..... | Under Constr | Mid 1960 | ..... | Olsen | Olsen |
| Susquehanna Western | Artesia, N.M. | Natural Gasoline | 35 MMcf | ..... | Under Constr | Fall 1960 | ..... | Staff | Staff |
| Texaco | Riverton, Wyo. | *Exp. Sulfuric Acid | to 75,000 tons/yr | ..... | Under Constr | ..... | ..... | ..... | ..... |
| Utah Oil Refining | Casper, Wyo. | Hydrotreater [illegible] | 4,500 bbls | ..... | Engineering | August 1960 | ..... | Texaco | Badger |
| | Salt Lake City, Utah | Exp. Cat Cracker, Alkylation, Tankage, Water Treating | ..... | $1,500,000 | Planning | 1960 | ..... | ..... | ..... |

## West Coast

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Allied Chemical | El Segundo, Cal. | Ammonium Sulfate | 56,000 tons/yr | ..... | Under Constr | Late 1960 | ..... | ..... | ..... |
| Borden Chemical | San Francisco | Resins | 25,000 tons/yr | ..... | Under Constr | ..... | ..... | ..... | ..... |
| | | Formaldehyde | 22,500 tons/yr | ..... | Under Constr | ..... | ..... | ..... | ..... |
| Collier Carbon & Chemical | Los Angeles | Sulfuric Acid | 250 tons | ..... | Engineering | Late 1960 | Leonard/Monsanto | Braun/Leonard/Monsanto | Braun |
| | | Ammonium Sulfate | 150 tons | ..... | Engineering | Late 1960 | ..... | Ebhart | |
| | Rodeo, Cal. | Carbon Calcining | ..... | ..... | Under Constr | Fall 1960 | | | ..... |
| | Wilmington, Cal. | Sulfuric Acid | ..... | ..... | Under Constr | Sept 1960 | Monsanto | Braun/Leonard | Braun |
| Continental Carbon | Bakersfield, California | *Carbon Black | 30,000,000 lbs/yr | $2,500,000 | Under Constr | Mid 1961 | ..... | ..... | ..... |
| Dow Chemical | Torrance, Cal. | Polypropylene | ..... | ..... | Planning | 1961 | ..... | ..... | ..... |
| | Kalama, Wash. | Phenol | 36,000,000 lbs/yr | ..... | Planning | Mid 1961 | ..... | ..... | ..... |
| Du Pont | Antioch, Cal. | Fluorinated Hydrocarbons, Tetraethyl Lead | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| Golden Eagle Ref. | Los Angeles | *Exp. Refinery | to 30,000 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| B. F. Goodrich | Watson, Cal. | Polyvinyl Chloride | ..... | ..... | Complete | ..... | ..... | S D | S D |
| Hercules Powder | Hercules, Calif. | Methanol | 8,000,000 gals/yr | ..... | Under Constr | Early 1961 | ..... | ..... | ..... |
| | | Urea-Formaldehyde Compositions | 11,000 tons/yr | ..... | Complete | ..... | ..... | ..... | ..... |
| | | Formaldehyde | 50,000,000 lbs/yr | ..... | Under Constr | Early 1961 | ..... | ..... | ..... |
| Mobil Oil | Torrance, Cal. | Exp Delayed Coker | 9,300 bbls | ..... | Complete | ..... | ..... | Bechtel/Staff | Bechtel |
| Northwest Petro-Chemical | Anacortes, Wash. | *Caustic Chemicals | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| Oronite Chemical | Richmond, Cal. | Maleric Anhydride | 20,000,000 lbs/yr | ..... | Complete | ..... | ..... | Badger Mfg | Badger Mfg |
| Richfield Oil | Everett, Wash. | Refinery | ..... | $50,000,000 | Planning | 1965 | ..... | ..... | ..... |
| Shell Chemical | Torrance, Calif. | *Isoamylene | ..... | ..... | Complete | ..... | ..... | ..... | ..... |
| Signal Oil & Gas | Bakersfield, Cal. | Exp. Refinery | 20,000 bbls | ..... | Under Constr | Late 1960 | ..... | Parsons | Parsons |
| Standard Oil (Calif) | Richmond, Cal. | Maleic Anhydride | 20,000,000 lbs/yr | ..... | Complete | ..... | | Badger | Badger |
| | | Polymers | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | Honolulu | Refinery | 35,000 bbls | $40,000,000 | Under Constr | 1961 | ..... | Staff/Bechtel | Bechtel/Hawaiian Dredging |
| Stauffer Chemical | Domingues, Calif. | *Exp. Sulfuric Acid | ..... | ..... | Complete | ..... | ..... | Staff | Staff |
| Texaco | Wilmington, Cal. | Catalytic Reformer | 12,000 bbls | ..... | Complete | ..... | ..... | ..... | ..... |
| | Los Angeles | *Hydrotreater | ..... | ..... | Engineering | ..... | ..... | Foster Wheeler | Foster Wheeler |
| Union Oil | Wilmington, Cal | Catalytic Reformer | 14,000 bbls | | | | | | |
| | | Mid-Barrel Unifiner | 20,000 bbls | $17,000,000 | Under Constr | Fall 1960 | Staff | Braun | Braun |
| | | Heavy Cat Unifiner | 4,000 bbls | | | | | | |
| | | Diesel-Oil Unifiner | 10,000 bbls | | | | | | |
| | | Gasoline Blending, Offsite Exp. | ..... | $1,500,000 | Engineering | ..... | ..... | Fluor | Fluor |
| | | CO Boiler | 240,000 lbs/hr | $2,500,000 | Engineering | Late 1960 | ..... | Fluor | Fluor |
| | | Amine Reactivator | 150 tons | $1,600,000 | Complete | ..... | ..... | Parsons | Parsons |
| | | $H_2S$ Recovery | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Valley Nitrogen | Helm, Cal. | Ammonia | 150 tons | ..... | Engineering | 1960 | Chemico | Chemico | Chemico |
| Wilshire | Santa Fe Springs, Cal. | Alkylation | 1,500 bbls | ..... | Complete | ..... | UOP | UOP/Braun | Staff/Braun |
| | Norwalk, Calif. | *Blending Facilities | ..... | ..... | Engineering | Late 1960 | ..... | Braun | Staff |

## Canada

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| British American Oil | Clarkson, Ont. | Compounding, Blending & Grease | ..... | $2,900,000 | Under Constr | ..... | ..... | Nofsinger | Foster Wheeler |
| | | Alkylation | 3,000 bbls | $3,000,000 | Complete | ..... | UOP | UOP | Procon |
| | Calgary | Exp. Combination, Crude Topping, Vacuum & Thermal Cracking | to 10,000 bbls | $600,000 | Under Constr | Sept 1960 | ..... | Staff | Staff |
| | | *Reformer Naphtha Desulfurizer | 3,500 bbls | $450,000 | Under Constr | Sept 1960 | ..... | Fluor | Fluor |
| | Moose Jaw Sask. | Cat Reformer | 5,400 bbls | ..... | ..... | ..... | ..... | ..... | ..... |
| British American Oil, et al | Rimbey, Alta. | *Gas Processing | 326 MMcf | $10,000,000 | Under Constr | Nov 1960 | ..... | Poole-Pritchard Canadian | Poole-Pritchard Canadian |
| British Petroleum | Ville d'Anjou | Crude Distl | 25,000 bbls | ..... | Complete | ..... | ..... | Lummus | Lummus |
| | | Cat Cracker | 9,000 bbls | ..... | Complete | ..... | UOP | Lummus | Lummus |
| | | Platformer | 6,000 bbls | ..... | Complete | ..... | UOP | Lummus | Lummus |
| | | Cat Desulfurizer | 12,000 bbls | ..... | Complete | ..... | ..... | Lummus | Lummus |
| | | Cat Polymerization | 700 bbls | ..... | Complete | ..... | UOP | Lummus | Lummus |
| | Montreal | *Propylene Recovery | ..... | $200,000 | Complete | ..... | ..... | Kellogg | Staff |
| | Clarkson | *Alkylation | 3,000 bbls | $3,100,000 | Complete | ..... | UOP | UOP | Procon |
| | | *Foul Condensate Stripper | ..... | $100,000 | Engineering | Fall 1960 | ..... | Staff | Staff |
| | Calgary | *Crude Revamp | to 10,000 bbls | $600,000 | Under Constr | ..... | ..... | Treco/Staff | Staff |
| | | *HDS | 3,500 bbls | $450,000 | Engineering | Oct 1960 | ..... | ..... | ..... |
| Canadian Chemicals | Edmonton, Alta | Revamp Petrochemicals | ..... | $4,000,000 | Engineering | Jan 1961 | ..... | Staff/B & R | Staff/B & R |
| | | Exp. Refinery | ..... | $4,000,000 | Planning | ..... | ..... | ..... | ..... |
| Canadian Oil | Carunna, Ont. | Unifiner | 5,000 bbls | ..... | Under Constr | 1960 | ..... | UOP | Procon |
| | Bowden, Alta. | Refinery | 4,500 bbls | $4,000,000 | Under Constr | Fall 1960 | UOP | Bechtel | Bechtel |
| Carbide Chemicals | Montreal East, Quebec | Exp. Ethylene Oxide, Oxide Derivatives 100% | ..... | ..... | Under Constr | Early 1961 | ..... | ..... | ..... |
| | | Exp. Polyethylene | to 65,000,000 lbs/yr | ..... | Under Constr | Late 1960 | ..... | ..... | ..... |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Carstairs Operators Committee | Carstairs, Alta. | Gas Processing | 66 MMcf | $3,500,000 | Complete | ..... | ..... | Fluor | Fluor |
| Cities Service Ref..... | Trafalgar, Ont. | *Avgas Blending | 500 bbls | $250,000 | Under Constr | Spring 1960 | ..... | Staff | Staff |
| | | *Asphalt | 500-1,000 bbls | $400,000 | Under Constr | Summer 1960 | ..... | Staff | Staff |
| | | *Distl Desulfurizer | 4,000 bbls | $500,000 | Planning | Late 1960 | ..... | ..... | ..... |
| Consolidated Mining & Smelting | Calgary, Alta. | Urea | 100 tons | $5,000,000 | Complete | ..... | Inventa-Vulcan | Vulcan/Braun | Cominco/Braun/Vulcan |
| Consumers Cooperative Refineries | Regina, Sask. | Naphtha Unifiner | 3,000 bbls | ..... | Under Constr | ..... | ..... | ..... | ..... |
| | | Platformer | 3,000 bbls | $2,500,000 | Engineering | Nov 1960 | UOP | Staff/UOP | ..... |
| Cyanamid of Canada | Welland, Ont. | Nitric Acid | 190 tons | ..... | Engineering | 1960 | Uhde | McKee | McKee |
| Imperial Oil..... | Edmonton, Alta. | Alkylation | 1,500 bbls | $2,175,000 | Complete | ..... | ..... | ..... | ..... |
| | Regina | Powerformer | 3,000 bbls | $2,550,000 | Complete | ..... | ..... | Canadian Kellogg | Canadian Kellogg |
| Innisfail Operators Committee..... | Innisfail Field, Alta. | Refinery | 10,000 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| | | Sulfur Recovery | 80 tons | ..... | Planning | ..... | ..... | ..... | ..... |
| | | Gas Treating | 8.7 MMcf | ..... | Planning | ..... | ..... | ..... | ..... |
| Irving Refining..... | St. John, New Brunswick | Hydrogen | ..... | ..... | Under Constr | 1960 | ..... | Girdler Bechtel | Canadian Bechtel |
| | | Crude Desalter | 38,500 bbls | ..... | Under Constr | 1960 | Howe-Baker | Bechtel | Bechtel |
| | | Gas Treating-Sulfur Recovery | ..... | ..... | Engineering | 1960 | ..... | Parsons | ..... |
| | | Refinery: | | | | | | | |
| | | Two-Stage Crude | 40,000 bbls | | | | | | |
| | | Catalytic Cracker | 13,000 bbls | | | | | | |
| | | Catalytic Reformer | 7,150 bbls | $45,000,000 | Under Constr | 1960 | ..... | Canadian Bechtel | Canadian Bechtel/Fluor |
| | | Hydrodesulfurization | 5,000 bbls | | | | | | |
| | | Hydrogen Treating | 2,500 bbls | | | | | | |
| Jefferson Lake Petrochemicals | Calgary, Alta. | Sulfur Recovery | ..... | ..... | Under Constr | Nov 1960 | ..... | ..... | ..... |
| | Savannah Creek, Alta. | Sulfur Recovery | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| Monsanto, Canada... | Villa La Salle, Que. | Maleic Anhydride | 6,000,000 lbs/yr | ..... | Planning | Late 1960 | ..... | SD | SD |
| Nevis Operators Committee | Nevis, Alta. | Gas Processing | 42 MMcf | $3,000,000 | Complete | ..... | ..... | Fluor | Fluor |
| | | Sulfur Recovery | 125 tons | | | | | | |
| Nottingham Gas Carnduff Gas | Saskatchewan | Gas Processing, Treating, Gathering | 8.5 MMcf | ..... | Engineering | 1960 | ..... | Tellepsen | Tellepsen |
| Polymer..... | Red Deer, Alta. | Butadiene | 30,000 tons/yr | $15,000,000 | Planning | ..... | ..... | ..... | ..... |
| Phillips Petroleum.... | Taylor, B.C. | Refinery, Natural Gas Liquids | ..... | ..... | Under Constr | 1960 | ..... | Stearns Roger | Stearns Roger |
| Regent Refining..... | Port Credit, Ont. | Catalytic Reformer | 4,700 bbls | $1,500,000 | Engineering | Fall 1960 | ..... | UOP | Catalytic |
| Sogemines..... | Maitland, Ont. | Synthetic Nitrogen, Ammonium Nitrate, Nitrogen Solutions, Anhydrous Ammonia | ..... | $17,000,000 | Planning | 1961 | ..... | ..... | ..... |
| | | *Partial Oxidation Gasification; Carbon Monoxide Conversion; Carbon Monoxide Removal | 15 MMcf | $1,800,000 | Under Constr | 1961 | ..... | Power-Gas | Power-Gas |
| Texaco, Canada..... | Montreal | Sulfuric Acid Alkylation Feed Preparation and Treating | 2,200 bbls | ..... | Under Constr | ..... | ..... | Foster Wheeler | Foster Wheeler |
| | | Vacuum Flashing | 30,000 bbls | ..... | Complete | ..... | ..... | Staff | ..... |
| Westcoast Transmission | Coleman, Alta. | Gas Processing | ..... | $15,000,000 | Planning | ..... | ..... | ..... | ..... |

## Latin America

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **ARGENTINA** | | | | | | | | | |
| Argentine Government | Santa Fe | Naphtha Reforming | 6,300 bbls | | Planning | ..... | ..... | ..... | ..... |
| | Mendoza | Topping, Delayed Coking, Catalytic Cracking | 28,300 bbls | $30,000,000 | Under Constr | Nov 1961 | Kellogg | Kellogg | Kellogg |
| | Salta | Naphtha Reforming | 3,150 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| | Buenos Aires | Lube Oil | 2,000 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| | Campo Duran Field | Lube Oil, Gasoline, Reforming | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| Carbometal..... | Mendoza | Polyvinyl Chloride | 4,500 tons/yr | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Acetylene | 200 tons/yr | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Plastics | 7,500 tons/yr | ..... | Planning | ..... | Monsanto | Monsanto | Monsanto |
| Diadema Argentina (Shell) | Buenos Aires | *Crude Distl. | 30,000 bbls | ..... | Planned | 1962 | ..... | ..... | ..... |
| | | *Cat Cracker | 16,000 bbls | ..... | Planned | 1962 | ..... | ..... | ..... |
| Esso S.A. P.A..... | Campana | *Crude | 41,000 bbls | ..... | Under Constr | Mid 1960 | E.R.E. | Staff | ..... |
| | | *Cat Cracker | 8,500 bbls | ..... | Engineering | Mid 1961 | E.R.E. | E.R.E./Kellogg | Tecnastar |
| Hooker Chemical.... | ..... | *Phenol | 25 tons | ..... | Under Constr | 1962 | ..... | ..... | ..... |
| -Atanor | | | | | | | | | |
| Monsanto..... | Buenos Aires | Phthalic Anhydride | ..... | ..... | Under Constr | ..... | ..... | Foster Wheeler | ..... |
| **BRAZIL** | | | | | | | | | |
| Alba ..... | Cubatao | Synthetic Methanol | 30 tons | ..... | Complete | ..... | Inventa/Vulcan | Vulcan-Cincinnati | Vulcan-Cincinnati |
| Industria Brasileira de Enxofre, S.A..... | Copuava, Sao Paulo | Sulfur Recovery | 25 long tons | $300,000 | Complete | ..... | ..... | Staff | Staff |
| North American Solvay | Sao Paulo | Ethylene Purification | 20 tons | ..... | Under Constr | 1960 | ..... | Hydrocarbon | Hydrocarbon/SETAL |
| Petroleo Brasileiro.... | Mataripe | Atmospheric & Vacuum Distl. | 52,000 bbls | $30,000,000 | Under Constr | 1960 | Kellogg | Kellogg | Kellogg Brasileira/Montreal, S A |
| | | Cat Cracker, Gas Recovery | | | | | | | |
| | | Wax Treating, Lube | | | | | | | |
| | Pernambuco State | Synthetic Rubber | 40,000 tons/yr | ..... | Planning | ..... | ..... | ..... | ..... |
| | Rio de Janeiro | Refinery | 90,000 bbls | $60,000,000 | Under Constr | 1961 | Houdry/UOP | Foster Wheeler | ..... |
| | Duque De Caxias Estad. Do Rio de Janeiro | Synthetic Rubber | 40,000 tons/yr | ..... | Under Constr | 1962 | ..... | Blaw Knox | ..... |
| | Cubatao-Sao Paulo | Exp. Refinery | 90,000 bbls | ..... | Under Constr | 1960 | ..... | Petrobras | ..... |
| | | Cat Reformer | 12,000 bbls | | | | | | |
| | | Aromatics Extr. | 3,000 bbls | $10,000,000 | Engineering | Mid 1962 | Houdry/UOP | ..... | ..... |
| | | Ethane Cracking | 3.77 MMcf | | | | | | |
| **CEN. AMERICA** | | | | | | | | | |
| Fertilisantes de Centro America (Ferticas), et al | Costa Rica | Nitrogen, Potash & Phosphorous Fertilizers, Urea | 650 tons | $10,000,000 | Planning | ..... | ..... | ..... | ..... |
| Matias de Calves..... | Puerto Barrios | Refinery | 3,500 bbls | ..... | Under Constr | ..... | ..... | Lummus | Lummus |
| Refineria Petrolera de Guatemala, et al | Matias, de Galves | Refinery | 12,000 bbls | ..... | Planning | ..... | ..... | ..... | ..... |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **COLOMBIA** | | | | | | | | | |
| International Petroleum (Colombia) | Cartagena | *Ammonia | 300 tons | $13,000,000 | Engineering | 1961 | ..... | Esso R & E | ..... |
| | ..... | *Nitric Acid | 150 tons | | | | | | |
| **GUATAMALA** | | | | | | | | | |
| Breaux Oil Refining... | Bridge Puerto Barrios | Refinery | 4,000 bbls | ..... | Planning | ..... | ..... | Lummus | Lummus |
| **MEXICO** | | | | | | | | | |
| Pemex..... | Minatitlan | *Anhydrous Ammonia | 200 tons | $8,000,000 | Under Constr | Mid 1961 | ..... | Fluor | Fluor |
| | | *Crude | 50,000 bbls | | Under Constr | Mid 1961 | ..... | Fluor | Fluor |
| | | *Cat Reformer | ..... | $23,000,000 | Under Constr | Mid 1961 | ..... | Fluor | Flour |
| | | *BTX | 4,800 bbls | | ..... | ..... | ..... | ..... | ..... |
| | Salamanco | *Anhydrous Ammonia | 200 tons | $8,000,000 | Under Constr | Late 1961 | ..... | Lummus | Lummus |
| | | *Topping | 40,000 bbls | $13,000,000 | Under Constr | Late 1961 | ..... | Lummus | Lummus |
| | | *Cat Reformer | | | | | | | |
| | | *Grease | 25 tons | $2,100,000 | Engineering | Mid 1961 | ..... | McKee | McKee |
| | Ciudad Madero | *Refinery | 135,000 bbls | $43,000,000 | Under Constr | March 1961 | ..... | McKee | McKee |
| | | *Cat Cracker | 110,000 bbls | | | | | | |
| | Poza Rica | *Topping | 15,000 bbls | $5,000,000 | Under Constr | Mid 1961 | ..... | McKee | McKee |
| | Atscapozalco | *Polyethylene | 25,000,000 lbs/yr | $8,000,000 | Engineering | Late 1961 | ..... | Simon Carver/ McKee | Simon Carver/ McKee |
| | Reynosa | *Exp. Absorption | 6 MMcf | ..... | Planning | ..... | ..... | ..... | ..... |
| | Cuidad Pemex | *Exp. Absorption | 7 MMcf | ..... | Planning | ..... | ..... | ..... | ..... |
| Synthesis Organicas... | Mexico City | *Exp. Phthalic Anhydride | ..... | ..... | Under Constr | 1960 | ..... | Foster Wheeler | ..... |
| **PANAMA** | | | | | | | | | |
| **Refiner a Petroquimica de Panama** | **Portobelo** | **Refinery** | **55,000 bbls** | **$40,000,000** | **Engineering** | **1961** | ..... | **Foster Wheeler** | **Foster Wheeler** |
| **Refineria Panama, S A** | **Las Minas Bay Colon** | **Refinery; Petrochemicals** | **70,000 bbls** | **$50,000,000** | **Under Constr** | Late 1962 | ..... | **Kellogg** | Bechtel |
| **TRINIDAD** | | | | | | | | | |
| **Federation Chemicals,** | **Point Lisas** | **Ammonium Sulfate** | **245 tons** | | | | **Stami-Carbon** | **Braun** | **Braun** |
| Shell Trinidad..... | Port Fortin | *Distl Revamp | 14,000 bbls | ..... | Under Constr | Late 1960 | ..... | ..... | ..... |
| **Texaco Trinidad**..... | **Pointe-a-Pierre** | **Crude Distl.** | **15,000 bbls** | ..... | **Under Constr** | ..... | **UOP** | **Procon** | **Procon** |
| | | Crude Topping | 100,000 bbls | ..... | Under Constr | Late 1960 | ..... | Fluor | Caribbean Bechtel |
| | | Cat Reformer | 15,000 bbls | ..... | Under Constr. | Late 1960 | ..... | Fluor | Caribbean Bechtel |
| | | Hydrotreater | 20,000 bbls | ..... | Under Constr | Late 1960 | ..... | Staff | Caribbean Bechtel |
| Administracion Nacional de Combustibles Alcohol Y Portland | La Teja | Vac. Distl. | 10,000 bbls | $10,500,000 | ..... | Late 1960 | ..... | Kellogg-/Staff | Staff |
| | | Cat Cracker | 5,000 bbls | | | | ..... | | |
| | | Cat Reformer | 3,000 bbls | | | | ..... | | |
| | | Gas Concent. & Bottling | ..... | | | | ..... | | |
| | | Gas Sweetening | 4,500 bbls | | | | ..... | | |
| | | Sulfur Recovery | 6 tons | | | | ..... | | |
| | | Power & Offsite Facilities | 3,600 kw | $1,500,000 | Under Constr | Late 1960 | ..... | | |
| | | CO Boiler | ..... | | | | ..... | ..... | ..... |
| | | *Atmospheric Distl with Desalter | 28,000 bbls | ..... | Complete | ..... | Howe Baker | ..... | ..... |
| **VENEZUELA** | | | | | | | | | |
| Creole Petroleum..... | Amuay Bay | *Isopentane | ..... | ..... | Under Constr | ..... | ..... | ..... | Foster Wheeler |
| **Mene Grande Oil**..... | Eastern Venesuela | **Compressor Stations** | ..... | ..... | **Engineering** | **Early 1960** | ..... | B & R | ..... |
| Mobil Oil de Venezuela | El Palito | Refinery | 50,000 bbls | $28,000,000 | Complete | ..... | ..... | Kellogg | Kellogg |
| | Eastern Venesuela | Compressor Stations | ..... | ..... | Complete | ..... | ..... | B & R | ..... |

# Europe and Africa

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **AFRICA** | | | | | | | | | |
| British Petroleum/ Shell Oil | Durban, Natal | Refinery | ..... | $70,000,000 | Planning | 1963 | ..... | ..... | ..... |
| S.A. Coal, Oil & Gas.. | ..... | *Hydrogen | ..... | ..... | Engineering | 1960 | Hercules | Power-Gas | ..... |
| Sociedade Nacional de Refinacao de Petroleos | Lourenco Marques, Mozambique | Refinery: | | | Under Constr | Early 1961 | ..... | Procon | Procon |
| | | Crude | 12,000 bbls | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Platformer | 2,500 bbls | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Diesel Fuel | 2,000 bbls | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Unifiner | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Merox | 1,500 bbls | ..... | ..... | ..... | ..... | ..... | ..... |
| Standard-Vacuum Refining of So. Africa | Durban, Natal | Exp. Asphalt | 4,500 bbls | $415,000 | Under Constr | 1960 | ..... | Staff | Fraser & Chalmers S.A. |
| | | Continuous Oxidiser | 300 bbls | | | | | | |
| **AUSTRIA** | | | | | | | | | |
| Power-Gas..... | Graz | *Catalytic Oil Gasification | 1.75 MMcf | ..... | ..... | ..... | Power-Gas | Didier | Didier |
| Oesterreich Mineraloelver-Waltung | Schwechat, Near Vienna | Crude Distl | 37,000 bbls. | ..... | Under Constr | Late 1960 | ..... | Lurgi | Lurgi |
| | | Cat Reformer | 7,000 bbls | ..... | Under Constr | 1961 | UOP | Lurgi | Lurgi |
| | | Gas Recovery | 14 MMcf | ..... | Under Constr | 1961 | ..... | Lurgi | Lurgi |
| | | Cat Cracker | 10,000 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| **Danubia Petrochemie A. G.** | **Schwechat near Vienna** | **Polypropylene** | **11,000,000 lbs/yr** | ..... | Complete | ..... | ..... | ..... | ..... |
| **BELGIUM** | | | | | | | | | |
| Amoco Fina..... | Antwerp | Petroleum Additives | ..... | ..... | Planning | Early 1961 | ..... | ..... | ..... |
| **Carbochimique**..... | **Tertre** | **Partial Oxidation Synthesis Gas** | **100-500 tons $NH_3$** | ..... | Complete | ..... | **Texaco** | **Power-Gas** | **Power-Gas** |
| | | **High Pressure CO Conversion** | **100-150 tons $NH_3$** | ..... | Complete | ..... | **Texaco** | **Power-Gas** | **Power-Gas** |
| **Cobenam, S.A.**..... | **Antwerp** | **Polyethylene** | **15,000 tons/yr** | ..... | Complete | ..... | ..... | **Union Carbide** | **Union Carbide** |
| | | *Ethylene | ..... | ..... | Engineering | 1961 | S & W | S & W | ..... |
| Raffinerie Belge de Petroles | Antwerp | *Gas-Oil Desulfurizer | 6,000 bbls | ..... | Under Constr | July 1960 | Institut Francois | Solemca | Solemca |
| | | *Two-Stage Vacuum Distl. | 5,000 bbls | ..... | Under Constr | Aug 1960 | Staff | Solemca | Staff |
| Union Chemique Belge | Ghent | *Phthalic anhydride | 5,000 tons/yr | $2,000,000 | Under Constr | Early 1961 | Sherwin Williams | Badger N.V. | Badger N.V. |
| **CANARY ISLANDS** | | | | | | | | | |
| Compania Espanola de Petroleos, S.A. | **Las Palmas** | **Ammonium Sulfate** | **365 tons** | ..... | **Engineering** | **Mid 1960** | **Uhde-Texaco** | **Uhde** | **Uhde** |
| | Teneriffe | *Crude Distl. | 50,000 bbls | $6,000,000 | Under Constr | Late 1961 | UOP | Procon | Procon |
| | | *Unifiner-Platformer | 15,000 bbls | | | | | | |
| | | *Boilers, Turbogenerators, tanks, Merox, Kerosine, Gas-Oil Unifining | ..... | $6,000,000 | Under Constr | 1962 | AEG & VKW Edeleanu | AEG & VKW | AEG & VKW |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Compania Insular del Nitrigeno, S.A. | Gran, Canaria | *Vacuum Distl.<br>*Ammonium Sulfate | 7,800 bbls<br>330 tons | .....<br>$10,500,000 | Under Constr<br>Under Constr | Mid 1961<br>Late 1960 | .....<br>Texaco Uhde, chemibau Linde | Foster Wheeler<br>Uhde, Man, Chemibau, Linde | Foster Wheeler<br>Uhde |
| **DENMARK** | | | | | | | | | |
| Dansk Vesdol | Kalundborg | Refinery | 20,000 bbls | ..... | Under Const | 1961 | ..... | Foster Wheeler | Foster Wheeler |
| Imperial Chemical Industries | Copenhagen | *Polyethylene | ..... | $11,200,000 | ..... | ..... | ICI | ..... | ..... |
| **ENGLAND** | | | | | | | | | |
| AE & CI | Modderfontein | *Synthethic Ammonia | 70,000 tons | ..... | Under Constr | 1960 | ..... | Staff/ICI/ Power-Gas | Power-Gas |
| British Chrome & Chemicals | Urlay Nook | *Sulfuric Acid | 100 tons | ..... | Under Constr | 1960 | Chemieban | Power-Gas | Power-Gas |
| British Petroleum | Isle of Grain | Special Solvents | 30,000 tons/yr | ..... | Under Constr | 1960 | ..... | Staff | ..... |
| | Kent | Special Solvents: Redistillation, Acid Washery | 30,000 tons/yr | ..... | Under Constr | 1960 | ..... | ..... | ..... |
| Distillers | ..... | *Monomer | ..... | ..... | Under Constr | ..... | ..... | Power-Gas | Power-Gas |
| **Esso Petroleum** | **Milford Haven** | **Atmospheric Distl**<br>**Powerformer**<br>**Hydrofiner**<br>**Electric Coalescer**<br>**Other Auxiliaries** | **100,000 bbls**<br>**16,500 bbls**<br>**16,500 bbls**<br>**31,500 bbls**<br>..... | ..... | **Under Constr** | **Late 1960** | ..... | **Foster Wheeler** | **Foster Wheeler** |
| | Fawley | Petroleum Additives | ..... | ..... | Under Constr | ..... | ..... | Foster Wheeler | Foster Wheeler |
| | | *Exp. Petrochemicals | ..... | ..... | Engineering | Jan 1961 | Esso | Foster Wheeler | Foster Wheeler |
| Imperial Chemical Industries | Wilton | Polypropylene | 10,000 tons/yr | ..... | Under Constr | Late 1960 | ..... | ..... | ..... |
| | | *Ammonium Nitrate Granulation | ..... | ..... | ..... | ..... | SBA | ..... | ..... |
| International Synthetic Rubber | Hythe | Exp. Butadiene-Styrene Rubber | to 90,000,000 lbs/yr | ..... | Planning | ..... | ..... | ..... | ..... |
| **Mobil Oil Co., Ltd.** | **Coryton** | **Crude Unit Exp.** | **5,000 bbls** | ..... | Complete | ..... | ..... | **Staff** | **Stat** |
| **Monsanto** | **Newport** | **Maleic Anhydride** | **15,000,000 lbs/yr** | ..... | **Under Constr** | **Late 1960** | **SD** | **SD** | **SD** |
| Northern Gas Board | Darlington | Catalytic Oil Gasification | 2 MMcf | ..... | Under Constr | ..... | ..... | Power-Gas | Power-Gas |
| North Eastern Gas Board | Whitby | Natural Gas Reforming | 1.25 MMcf | ..... | Engineering | 1960 | Hercules | Power-Gas | Power-Gas |
| Oronite Chem. | ..... | *p-Xylene, Oxylene, Benzene, Ethyl Benzene | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| **South Eastern Gas** | **Isle of Grain** | **Hydrogen** | **18 MMcf** | ..... | **Under Constr** | **Late 1960** | ..... | **Woodall-Duckham** | **Woodall-Duckham** |
| Union Carbide | Fawley | Ethylene Oxide & Derivatives | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| UK Atomic Energy Authority | ..... | High Purity Nitrogen | ..... | ..... | Under Constr | 1960 | Petrocarbon | Petrocarbon | Petrocarbon |
| Woodall Duckham | Fulham | *Producer Gas | 15 MMcf | ..... | Engineering | Oct 1961 | H & G | H & G | H & G |
| **FRANCE** | | | | | | | | | |
| Antar-Petroles de l'Atlantique | Donges | Crude Topping | 62,000 bbls | ..... | Engineering | 1961 | ..... | Technip | Technip |
| **Compagnie de Raffinage Shell Berre** | **Petit Couronne** | **Distl.** | **80,000 bbls** | ..... | Complete | ..... | ..... | ..... | ..... |
| | | **Hydrodesulfuriser** | **11,000 bbls** | ..... | Complete | ..... | ..... | ..... | ..... |
| | | **Platformer** | **14,000 bbls** | ..... | Complete | ..... | ..... | **Procon** | **Procon** |
| | **Berre l'Etang** | **Furfural** | **3,500 bbls** | ..... | Complete | ..... | ..... | **Foster Wheeler** | **Foster Wheeler** |
| Comp Francaise de Raffinage | Gonfreville l'Orcher | **Ethylene** | 20,000 tons/yr | ..... | Complete | ..... | ..... | **Kellogg Int'l.** | ..... |
| **Compagnie Francaise de Petrole/ Compagnie Francise de Raffinage/ Pechelbronn** | **Strasbourg** | **Refinery** | **70,000 bbls** | ..... | **Planning** | ..... | ..... | ..... | ..... |
| Ethyl Synthese | Masingarbe | *Styrene Monomer | ..... | ..... | Complete | ..... | Koppers | SBA | SBA |
| **Esso Standard** | **Port Jerome** | **Additives Plant** | ..... | ..... | Complete | ..... | ..... | Foster Wheeler | Foster Wheeler |
| | | *Lube Hydrofiner | ..... | ..... | Under Constr | 1961 | Esso R&E | Esso R & E/ Lummus | Lummus |
| Methanolacq | Pardies, pres Lacq | Methanol | 100 tons | ..... | Complete | ..... | ..... | Kuhlmann/STEC | ..... |
| **Mobil Oil Francaise** | **Gravenchon** | **Lube Exp.** | ..... | ..... | Complete | ..... | ..... | ..... | ..... |
| **Naphtachimie** | **Lavera** | **Exp. Ethylene Oxide** | **60,000,000 lbs/yr** | ..... | Under Constr | 1960 | S D | SFST | SFST |
| | | Exp. Butadiene Recovery | 8,000 tons/yr | ..... | Planning | ..... | ..... | Foster Wheeler | Foster Wheeler |
| | | Cat Cracking, Gas Separation | ..... | ..... | Under Constr | 1960 | ..... | S & W | S & W |
| | | Ethylene Glycol | ..... | ..... | Under Constr | 1960 | ..... | Naphthachimie | ..... |
| | | Propylene Oxide | ..... | ..... | Under Constr | 1960 | ..... | Naphthachimie | ..... |
| | | *Propylene | ..... | $1,000,000 | Under Constr | Early 1961 | ..... | Badger N.V./ Badger France | Badger France |
| Northern Gas Board | Darlington | *Catalytic Oil Gasification | 2 MMcf | ..... | Complete | ..... | Power-Gas | Power-Gas | Power-Gas |
| | Whitby | *Natural Gas Reforming | 1.25 MMcf | ..... | Under Constr | 1960 | Hercules | Power-Gas | Power-Gas |
| **Omnium Francais de Petroles** | | **Refinery** | **75,000 bbls** | ..... | **Planning** | ..... | ..... | ..... | ..... |
| Oronite Chemical/ Societe Colifornie-Atlantique | Donges | p-Xylene | ..... | ..... | Planning | 1960 | ..... | ..... | ..... |
| Pechiney/Dow | Ribecourt | Polystyrene | ..... | ..... | Planning | 1961 | ..... | ..... | ..... |
| Societe Francaise Des Petroles BP | Lavera | *Hydrogenation of Steam Craking Gasoline | 3,500 bbls | $850,000 | Complete | ..... | BP | Technip | Technip |
| **Societe des Produits d'Aquitaine** | Chimique | **Ammonia** | **200 tons** | **$6,000,000** | **Engineering** | 1960 | ..... | **Chemico** | **Chemico** |
| | **Lacq** | **Acetylene from Nat. Gas** | **75 tons** | ..... | **Under Constr** | ..... | **BASF** | **BASF/Heurtey** | **Heurtey** |
| **Soc. Francaise des Petroles BP** | **Lavera** | **Selective Hydrogenation** | **3,500 bbls** | ..... | Complete | ..... | ..... | ..... | **Technip** |
| Soc. Nationale des Petroles D'Aquitaine | Lacq | Desulfurization | 350 MMcf | ..... | Under Constr | 1960 | ..... | Foster Wheeler | Staff |
| | | Sulfur Recovery | 2,000 tons | ..... | Complete | ..... | Parsons | Parsons/Huerty | Staff |
| | | Natural Gasoline | 240 MMcf | ..... | Under Constr | 1961 | ..... | Lummus | Staff |
| | | Ethylene | 25,000 tons | ..... | Under Constr | 1960 | ..... | Hydrocarbon | Staff |
| | | *Preliminary Desulfurization | 350 MMcf | ..... | Under Constr | 1960 | ..... | Technip | Staff |
| Soc. Vinylacq | Lacq | *Vinyl Chloride | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| United Carbon | Rouen | Carbon Black | 50,000,000 lbs/yr | $5,000,000 | Planning | 1961 | ..... | ..... | ..... |
| **EAST GERMANY** | | | | | | | | | |
| DIA Chemie Ausruestung Berlin | Leuna | Ethylene Aromatics | 300,000 lbs | $12,000,000 | Engineering | 1962 | Petrocarbon | Petrocarbon/ H & G | Staff/H & G |
| German Democratic Republic | Lenna | *Ethylene | 40,000 tons/yr | $12,000,000 | Engineering | ..... | Petrocarbon | H & G | ..... |
| Leuna-Werk Walter Ulbricht | ..... | Urea | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | | Ammonium Nitrate | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | | Exp. Nitrogen | to 400,000 tons/yr | ..... | Planning | 1965 | ..... | ..... | ..... |
| Piersterits Nitrogen | ..... | Exp. Nitrogen | to 20,000 tons/yr | ..... | Planning | 1961 | ..... | ..... | ..... |
| **WEST GERMANY** | | | | | | | | | |
| **B.P. Benzin und Petroleum** | **Dinslaken** | **Distillation, Cat Reforming, Hydroforming, Copper Chloride** | **100,000 bbls** | ..... | **Under Constr** | **1960** | ..... | **Kellogg** | ..... |
| Buna Werke Huls | Marl, Kreis Recklinghausen | Exp. Synthetic Rubber | 42,000 tons/yr | ..... | Complete | ..... | ..... | ..... | ..... |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Chemische Fabrik Holten | Lubwigshaven a Rein | Ethylene Oxide | 9,000,000 lbs/yr | ..... | Under Constr | ..... | S D | S D | ..... |
| Chemische Werke Huls | Marl | Polyethylene | 6,000 tons/yr | ..... | Planning | 1960 | Ziegler | Staff | Staff |
| Deutsche Erdoel | Heide | Exp. Refinery | 50,000 bbls | ..... | Planning | 1963 | ..... | ..... | ..... |
| Deutsche Shell | Godorf | *Refinery w/Cat Reformer, Desulfuriser | 40,000 bbls | ..... | Complete | ..... | ..... | ..... | ..... |
| Durag-Nerag | Misburg, Hannover | Platformer, Sulfur Recovery | 4,500 bbls. | ..... | Engineering | Sept 1960 | UOP | Lurgi | Lurgi |
| Deutsche Shell | Harburg | Delayed Coker<br>Selective Cracker<br>Natural Gasoline | 3,000 tons<br>21,000 bbls | ..... | Under Constr | ..... | ..... | Lummus | Lummus |
| | | Refinery:<br>Crude Distiller<br>Cat Reformer<br>Hydrodesulfurization | 40,000 bbls | ..... | Under Constr | ..... | ..... | Lummus | ..... |
| | Godorf | Refinery | 30,000 bbls | ..... | Under Constr | 1960 | ..... | ..... | ..... |
| Erdolchemie | Dormagen/ Niederrhein | Propylene Oxide | 20,000 tons/yr | ..... | Under Constr | 1960 | Farbenfabriken/ Bayer | Farbenfabriken/ Bayer | Farbenfabriken/ Bayer |
| | | Ethylene | 200,000 tons/yr | ..... | Under Constr | 1960 | ..... | S & W | S & W |
| | | Ethanol | 18,000 tons/yr | ..... | Under Constr | 1960 | Shell | S & W | S & W |
| | | Butadiene | 30,000 tons/yr | ..... | Under Constr | Late 1960 | Esso | Lurgi | Lurgi |
| | | Gasoline Selective Hydrogenation | 90,000 tons/yr | ..... | Under Constr | 1360 | BP | BP/Lurgi | Lurgi |
| | | Di-isobutane | 30,000 tons/yr | ..... | Engineering | Late 1960 | ..... | Kellogg International | Kellogg International |
| Esso A.G. | Koln | *Steam Cracker, Ethylene Recovery, Petrochemicals | ..... | $11,000,000 | Engineering | June 1961 | Esso R&E | Lurgi | ..... |
| Gelsenberg Benzin AG | Gelsenkirchen | *Platformer | 12,500 bbls | $5,300,000 | Under Constr | Dec 1960 | UOP | Lurgi | ..... |
| Gewerkschaft Erdol-raffinerie Emsland | Lingen Holthausen | Crude | 32,000 bbls | ..... | Complete | ..... | ..... | Lurgi | Lurgi |
| | | Unifiner-Platformer | 4,700 bbls | ..... | Planning | ..... | UOP/ Shell | Lummus | Lummus |
| | | Gas Oil Desulfuriser | 5,500 bbls | ..... | Planning | ..... | UOP/ Shell | Lummus | Lummus |
| | | Kerosine Desulfurization | 270 tons | ..... | Complete | ..... | ..... | Lurgi | Lurgi |
| | | Gasoline Desulfurization | 207 tons | ..... | Complete | ..... | ..... | Lurgi | Lurgi |
| Frisia | Emden | Refinery | 30,000 bbls | $17,000,000 | Engineering | 1960 | ..... | Parsons | Parsons |
| Oelwerke Julius Schindler | Hamburg-Neuhof | *Lube Oil Dewaxing | 2,500 bbls | $4,000,000 | Under Constr | Early 1961 | Edeleaner | Edeleaner | Edeleaner |
| Ali-Chemie | Bad Honningen | Hydrogen | ..... | ..... | ..... | 1960 | Hercules | Power-Gas | Power-Gas |
| Oronite Chemical, B.P. | ..... | *P-xylene, O-xylene, Benzene, Ethyl Benzene | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| Rheinische Olefinwerke | Wesseling Bes., Kohn | Ethylene | 75,000 tons | ..... | Under Constr | Early 1961 | ..... | Braun | Staff |
| | Koln | Ethylene | ..... | ..... | Engineering | Jan. 1961 | Kellogg | Braun/Lurgi | ..... |
| Ruhrchemie | Oberhausen-Holten | Polyethylene | ..... | ..... | Under Constr | 1960 | Staff | Ubde | Staff/Ubde |
| Westdeutsch Erdolleitungs | Ruhlermoor | Crude Desalter | 5,700 bbls | ..... | Engineering | 1960 | Howe-Baker | Ubde | Ubde |
| **GREECE** | | | | | | | | | |
| Dow Chemical | ..... | Polystyrene Plastic | ..... | $1,000,000 | Planning | Early 1961 | ..... | ..... | ..... |
| Greek Government | Ptolemaeus, Greece | Ammonia<br>Ammonium Sulfate<br>Ammonium Nitrate | 300 tons<br>525 tons<br>325 tons | ..... | Engineering | Mid 1962 | Ubde, Casale | Ubde, Casale | Ubde, Casale |
| | Aspropygas | *LPG | 25,000 tons/yr | ..... | Planning | ..... | ..... | ..... | ..... |
| **IRELAND** | | | | | | | | | |
| Carbide Industries | Londonderry | *Producer Gas | 4 MMcf | ..... | Complete | ..... | H&G | H&G | H&G |
| Scottish Gas Board | Fifeshire | *Stage 1, Pressure Gasification | 5 MMcf | ..... | Under Constr | Late 1960 | Lurgi, et al | H&G | H&G |
| | | *Stage 2, Pressure Gasification | 15 MMcf | ..... | Engineering | ..... | Lurgi, et al | H&G | G&H |
| **ITALY** | | | | | | | | | |
| Aziende Colori Nazionali Affini | Cengio | Phthalic Anhydride | 22,000,000 lbs/yr | ..... | Complete | ..... | Badger Mfg | Badger Mfg | Badger Mfg |
| Asfalti Bitumi Cementie Derivati, S.A. | Ragusa | Polyethylene | 25 tons | ..... | Under Constr | ..... | ..... | BASF | ..... |
| Azienda Nazionale Idrogenazione Combustibil | Ravenna | Styrene Monomer | 14,000 tons/yr | ..... | Complete | ..... | Koppers | SBA | SBA |
| | | Butadiene | 22,000 tons/yr | ..... | Engineering | 1960 | Houdry | Catalytic | ..... |
| | | Ethylene | ..... | ..... | Under Constr | ..... | Koppers | ANIC | ..... |
| Cabot Italiana | Revenna | Carbon Black | 85,000 bls | $3,000,000 | Complete | ..... | Cabot | Cabot | Techint |
| Dow Chemical Italiana | ..... | Polystyrene | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| Ftalital, S.p.a. | Italy | Maleic Anhydride | 2,200,000 lb/yr | ..... | Engineering | ..... | S D | S D | ..... |
| Italgas | Rome | High-Btu Oil Gas | 1.8 MMcf | ..... | Complete | ..... | Semet Solvay | Power-Gas/ SAFII | Power-Gas/ SAFII |
| Malta Gas Board | Valetta | *Catalytic Oil Gasification | 1 MMcf | ..... | Complete | ..... | Power-Gas | Power-Gas | Power-Gas |
| Mobil Oil Italiana | Naples | Cat Reforming | 9,000 bbls | ..... | Complete | ..... | ..... | CTIP | CTIP |
| | | Cat Hydrodesulfurization | 10,000 bbls | ..... | Complete | ..... | ..... | CTIP | CTIP |
| | | Lube Exp. | ..... | ..... | Complete | ..... | ..... | Staff | Staff |
| Montecatini Societe Generale per l'Industria Mineraria Chimica | Ferrara | Exp. Polypropylene | ..... | ..... | Planning | 1960 | ..... | ..... | ..... |
| | Castellanza | Exp. Formaldehyde | 135,000,000 lbs/yr | $300,000 | Under Constr | ..... | ..... | ..... | ..... |
| | Brindisi | Petrochemical | 700,000 tons/yr | $95,000,000 | Under Constr | 1962 | ..... | ..... | ..... |
| Phillips Petroleum & ANIC | ..... | Carbon Black | 25,000,000 lbs/yr | ..... | Planning | 1962 | Phillips | ..... | ..... |
| Purfina Italiana | Rome | *Refinery | 20,000 bbls | $10,000,000 | Planning | 1962 | ..... | ..... | ..... |
| | Genoa | *Topping Revamp | 13,000 bbls | $500,000 | Engineering | 1961 | ..... | Staff | Staff |
| | | *Trickle Hydrodesulfurization | 2,200 bbls | $500,000 | Engineering | 1961 | Shell | CTIP | Staff |
| Sincat | Priolio, Sicily | Ethylene | ..... | ..... | Under Constr | 1960 | S & W | S & W | ..... |
| | | Treating | ..... | ..... | Engineering | 1960 | ..... | S & W | ..... |
| Snia Viscosa | Varedo, near Milan | Carbon Disulfide | ..... | ..... | Under Constr | 1960 | Food | ..... | ..... |
| Stanic Industria Petrolifera | Livorno | Naphtha Stabilizer and Splitter | 11,000 bbls | $683,000 | Complete | ..... | ..... | Esso | CTIP |
| Union Carbide Societa Edison S.A. | Sicily | Polyethylene | 15,000 tons/yr | ..... | Under Constr | 1960 | ..... | ..... | ..... |
| | Celene | Ethylene Oxide | 26,500,000 lbs/yr | ..... | Under Constr | 1960 | ..... | ..... | ..... |
| Malta Gas Board | Valetta | Catalytic Oil Gasification | 1 MMcf | ..... | Under Constr | 1960 | ..... | Power-Gas | Power-Gas |
| **NETHERLANDS** | | | | | | | | | |
| Esso Nederland | Rotterdam | Refinery | 95,000 bbls | $50,000,000 | Complete | ..... | Esso | Esso | Badger N.V. |
| N.V. Mattschappij Tot Exploittatie Van Kooksovengossen | Ijmuiden | Gas Reforming | 4.4 MMcf | ..... | Planning | ..... | ..... | ..... | ..... |
| | | CO Conversion | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| Staatsmijner in Limburg | Geleen, Holland | Phthalic Anhydride | ..... | ..... | Under Constr | 1960-1961 | S D | SFST | ..... |
| **NORWAY** | | | | | | | | | |
| A/S Esso-Raffineriet, Norge | Slagentangen (Oslo Fjord) | *Refinery | 40,000 bbls | ..... | Under Constr | Late 1960 | Esso | Bechtel | Bechtel-Sverdrup |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **POLAND** | | | | | | | | | |
| Polimex | Oswiecim | Polystyrene | 35,000 lbs | $1,500,000 | Under Constr | 1960 | Petro-carbon | Petrocarbon | Staff |
| Polish Government | Plock | Refinery | 40,000 bbls | ..... | Planning | 1965 | ..... | ..... | ..... |
| | | Hydrogen | 1.5 MMcf | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Fuel Gas | 11 MMcf | ..... | ..... | ..... | ..... | ..... | ..... |
| **RUMANIA** | | | | | | | | | |
| Rumanian Govt. | Teleajen | Lube Oil | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | | Natural Gas Treating | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | Borzesti | Petrochemical | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | Onesti | Synthetic Rubber | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| **SCOTLAND** | | | | | | | | | |
| British Hydrocarbon Chemicals | Grangemouth | Ethylene | 70,000 tons/yr | ..... | Complete | ..... | ..... | S & W Ltd | S & W Ltd |
| | | Exp. Styrene Monomer | 50,000 tons | ..... | Under Constr | Dec 1960 | Mon-santo | Monsanto | Matthew-Hall |
| | | Gasoline Treater | ..... | ..... | Complete | ..... | BP | Lummus | Lummus |
| | | *Methanol | ..... | ..... | Planning | 1961 | ..... | Chemico | Chemico |
| | | *Butadiene | ..... | ..... | Planning | 1961 | Esso | Fluor | Flour |
| | | *Ethylene Dichloride | ..... | ..... | Planning | 1961 | Ethyl | Lummus | Lummus |
| **SOUTH AFRICA** | | | | | | | | | |
| AE & CI | Modderfontein | Synthetic Ammonia | 70,000 tons | ..... | Under Constr | 1960 | ..... | Staff/ICI/ Power-Gas | Power-Gas |
| Phillips Petroleum-Industrial Development | | Carbon Black | 22,000,000 lbs/yr | ..... | Under Constr | ..... | Staff | Staff | Staff |
| Standard Vacuum | Durban | Exp. Asphalt Oxidiser | 2,100 bbls<br>600 bbls | $415,000 | Under Constr | 1960 | ..... | Staff | ..... |
| **SPAIN** | | | | | | | | | |
| Repesa | Escombreras (Marcia) Spain | *Ammonia<br>*Ammonium Sulfate<br>*Urea<br>*Sulfuric Acid | 325,000,000 lbs<br>600,000 tons<br>210,000 tons<br>455,000 tons | $32,000,000 | Engineering | 1962 | Texaco | Foster Wheeler<br>Uhde<br>Chemico<br>Braun | Foster Wheeler<br>Uhde<br>Chemico<br>Braun |
| **SWITZERLAND** | | | | | | | | | |
| Miranco | Mendrisio | *Lube Oils | 500 bbls | $1,500,000 | Under Constr | Late 1960 | ..... | Staff | ..... |
| Power-Gas | Winterthur | Catalytic Oil Gasification | 606 Mcf | ..... | Under Constr | ..... | Power-Gas | Power-Gas Didier | Power-Gas Didier |
| **TURKEY** | | | | | | | | | |
| Istanbul Petrol Raffinerisi Anonim Sirkett (Caltex & Turkish Govt.) | Izmit | *Refinery: Crude Distl. Naphtha Uni-finer, Platformer, Distillate Hydrotreater, Cat Cracker | 20,800 bbls | ..... | Engineering | Jan 1962 | ..... | Kellogg | Kellogg |
| **U.S.S.R.** | | | | | | | | | |
| Techmachimport | Angarsk, Siberia | Polystyrene | 5,000 tons/yr | $1,800,000 | Engineering | ..... | Bx Plas-tics | Power Gas | ..... |
| | | *Acetylene | ..... | ..... | Engineering | ..... | SBA | SBA | SBA |
| | | *Synthetic Ammonia | ..... | ..... | Engineering | ..... | SBA | SBA | SBA |
| **YUGOSLAVIA** | | | | | | | | | |
| Yugoslav Govt. | Sisak | *Topping<br>*Delayed Coking<br>*Platforming | 15,000 bbls<br>4,950 bbls<br>3,020 bbls | $10,000,000 | Planning | Spring 1963 | ..... | ..... | ..... |
| | Kutina | *Ammonia | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | Zogreb | *Petrochemicals | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| | Rijeka | *Topping | 1,000,000 tons/yr | ..... | Planning | ..... | ..... | ..... | ..... |
| | | *Delayed Coking | 125,000 tons/yr | | | | | | |
| | | *Naphtha Rerunning | 140,000 tons/yr | | | | | | |
| | | *Platforming | 100,000 tons/yr | | | | | | |
| | | *Sulfur Recovery | 5,000 tons/yr | | | | | | |
| | Bosanski Brool | *Topping | 640,000 tons/yr | ..... | Planning | ..... | ..... | ..... | ..... |
| Fabrika Asonih Dubriva | ..... | *High-Pressure Desulfurisation | ..... | ..... | Planning | ..... | ..... | Pintsch Bamag | Pintsch Bamag |

## *Near East*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **ALGERIA** | | | | | | | | | |
| Cie Francaise des Petroles | Algiers | Refinery | 44,000 bbls | ..... | Engineering | 1962 | ..... | ..... | ..... |
| **EGYPT** | | | | | | | | | |
| Anglo-Egyptian Oil-fields | Suez | Cat Reformer | 2,300 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| Egyptian Chem. Ind./ KIMA S.A.E. | Aswan | Ammonia | 415 tons | ..... | Under Constr | 1960 | Uhde/ BASF | Uhde/BASF | Uhde/BASF |
| Egyptian Government | Suez | Power | 10,000 KW | $2,300,000 | Planning | 1960 | ..... | ..... | ..... |
| | | Atmos. Distl., Vac. Distl. & Lube Oils | 20,000 bbls | $7,000,000 | Planning | 1960 | ..... | ..... | ..... |
| | | Cat Reformer | 3,000 bbls | $2,700,000 | Planning | 1962 | ..... | ..... | ..... |
| | | Hydrodesulfuriser | 2,700 bbls | $720,000 | Planning | 1962 | ..... | ..... | ..... |
| | | Lube Oils | ..... | $9,000,000 | Planning | 1963 | ..... | ..... | ..... |
| | Alexandria | Atmos. & Vac., Distl. | 10,000 bbls | $1,400,000 | Planning | ..... | ..... | ..... | ..... |
| | Cairo | Atmos. Distl. & Vac., Distl. | 10,000 bbls | $1,400,000 | Planning | ..... | ..... | ..... | ..... |
| **IRAN** | | | | | | | | | |
| Iranian Govt. | Shiraz | *Nitric Acid | 30,000 tons/yr | $30,000,000 | Under Constr | ..... | SBA | SBA/Foster Wheeler | ..... |
| | | *Ammonium Nitrate | ..... | ..... | Under Constr | ..... | SBA | SBA/Foster Wheeler | ..... |
| **IRAQ** | | | | | | | | | |
| Iraq Government | Baghdad | Refinery Exp. | 4[illegible],000 bbls | $11,000,000 | Complete | ..... | ..... | Foster Wheeler | Foster Wheeler |
| | | Powerformer | 5,000 bbls | ..... | Complete | ..... | ..... | Foster Wheeler | Foster Wheeler |
| | | Kerosine Treating | 5,000 bbls | ..... | Complete | ..... | ..... | Foster Wheeler | Foster Wheeler |
| | | Synthesis Gas | 121 tons | | Complete | ..... | ..... | Foster Wheeler | ..... |
| Iraq Petroleum | Kirkuk | *Oil Sweetening | 250,000 bbls | $1,250,000 | Under Constr | ..... | ..... | Foster Wheeler | Foster Wheeler |
| **KUWAIT** | | | | | | | | | |
| Kuwait Oil | Mina al Ahmadi | Bulk LPG | 8,000 bbls | ..... | Engineering | 1961 | ..... | Wimpey-Bechtel International | Wimpey-Bechtel |
| **MOROCCO** | | | | | | | | | |
| Ente Nazionale Idrocarburi | Mohammedia | Refinery | 25,000 bbls | ..... | Under Constr | 1962 | ..... | ..... | ..... |
| **PAKISTAN** | | | | | | | | | |
| Pakistan Industrial Development | Fnchanj, Pakistan | Ammonia<br>Urea | 225 tons<br>375 tons | $20,000,000 | Engineering | 1961 | Kobe Steel | Chemico | Chemico |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| Standard Vacuum Oil, et al | Korangi | Refinery:<br>Crude Distl<br>Hydrotreater<br>Catalytic Reformer | 32,000 bbls | $35,000,000 | Engineering | ..... | ..... | ..... | ..... |
| Sui Carbon | ..... | Carbon Black | 36,000,000 lbs/yr | ..... | Planning | ..... | ..... | ..... | ..... |
| **SAUDI ARABIA** | | | | | | | | | |
| **Arabian American Oil** | **Ras Tanura** | **Alkylation**<br>**LPG**<br>**Asphalts** | **1,210 bbls**<br>**1,500 bbls** | **$6,980,000**<br>**$1,025,000** | **Under Constr**<br>**Engineering**<br>Under Constr | **1960**<br>**1961** | **Kellogg**<br>**Kellogg** | **Kellogg/Staff**<br>**Staff** | **Staff**<br>**Staff** |
| United Arab Republic | Suez | *Exp. Refinery | ..... | ..... | Engineering | ..... | UOP/ Others | Braun | ..... |
| | Khursaniya | *Gas-Oil Separation | ..... | ..... | Complete | ..... | ..... | Bechtel | Bechtel |
| Arabian Oil of Japan | Kuwait | *Topping & Utilities | 20,000 bbls | ..... | Planning | 1962 | ..... | ..... | ..... |
| | | *Refinery | 50,000 bbls | ..... | Planning | 1965 | ..... | ..... | ..... |
| **TURKEY** | | | | | | | | | |
| Caltex, Standard Oil (Calif.), Turkish Govt. | Ismit | Refinery:<br>Crude Distl<br>Naphtha Unifiner<br>Platformer<br>Distillate Hydrotreater<br>Catalytic Cracker | 20,800 bbls | $26,000,000 | Engineering | ..... | ..... | ..... | Kellogg |
| Caltex | Istanbul | Refinery | ..... | ..... | Engineering | ..... | ..... | ..... | ..... |
| Mobil International, Royal Dutch Shell BP | Mersin | Refinery | 65,000 bbls | $50,000,000 | Under Constr | Late 1961 | ..... | Foster Wheeler | Foster Wheeler |

## *Far East*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licensor | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **COMMUNIST CHINA** | | | | | | | | | |
| | Lanchow<br>Shenyan | Refinery | ..... | ..... | Under Constr | ..... | ..... | ..... | ..... |
| **FORMOSA** | | | | | | | | | |
| Chinese Petroleum | Kaohsiung | *Unifiner | 5,500 bbls | $900,000 | Engineering | Late 1960 | Union Oil | Fluor/Staff | Staff |
| | | *Alkylation | 900 bbls | $1,300,000 | Complete | ..... | Texaco | Badger | Staff |
| **HONG KONG** | | | | | | | | | |
| **Hong Kong & China Gas** | **Hong Kong** | **Cat Oil Gasification** | **1.5 MMcf** | ..... | Complete | ..... | Power-Gas | **Power Gas** | **Power Gas** |
| **INDIA** | | | | | | | | | |
| Fertilizers & Chemicals Travancore | ..... | *Partial Oxidation Gasification | ..... | ..... | Engineering | ..... | Texaco | Power-Gas | Power-Gas |
| | | *Carbon Monoxide Pressure Conversion | ..... | ..... | Engineering | ..... | Power-Gas | Power-Gas | Power-Gas |
| | | *Carbon Dioxide & Hydrogen Sulphide Removal | ..... | ..... | Engineering | ..... | Power-Gas | Power-Gas | Power-Gas |
| Oil India Private | Noonmati, Assau | Refinery | 750,000 tons/yr | $10,500,000 | Under Constr | April 1961 | Indian Govt | Rumanian Govt | Rumanian Govt |
| | Barauni | Refinery | 40,000 bbls | ..... | Planning | 1962 | ..... | USSR Govt | USSR Govt. |
| **National Carbon** | **Bombay** | **Polyethylene** | ..... | ..... | Complete | ..... | ..... | **B & R** | **B & R** |
| Neyveli Lignite | Neyveli | Urea | 500 tons | $52,500,000 | Engineering | Early 1963 | ..... | Montecatini/ Ansaldo | Montecatini/ Ansaldo |
| **Sahu Chemicals** | **Varanasi** | **Ammonium Chloride**<br>**Soda Ash Fertilizer** | **120 tons**<br>**120 tons** | ..... | **Under Constr**<br>**Under Constr** | **1960**<br>**1960** | **Uhde**<br>**Pintsch/ Bamag** | **Uhde**<br>**Pintsch/Bamag** | **Uhde**<br>**Pintsch/Bamag** |
| | | **Ammonia** | **120 tons** | ..... | **Under Constr** | **1960** | **John Thompson** | **CECIP** | **John Thompson** |
| **Standard Vacuum** | **Bombay** | **Asphalt** | **125,000 tons/yr** | **$2,500,000** | **Under Constr** | **1960** | ..... | **Parsons** | **Parsons** |
| **INDONESIA** | | | | | | | | | |
| **Indonesian Government** | **Palembang, Sumatra** | **Urea Fertilizer** | **330 tons** | ..... | **Under Constr** | ..... | ..... | **Foster Wheeler** | **Foster Wheeler** |
| **JAPAN** | | | | | | | | | |
| **Asahi Chemical Industries** | **Nobeoka** | **$NH_3$ Synthesis Gas** | **50 metric tons** | **$3,670,000** | **Under Constr** | **1960** | **Texaco/ Chemico** | **Chemico** | **Chemico** |
| Asia Oil | Yokohama | Unifiner | 3,000 bbls | ..... | Engineering | June 1961 | UOP | UOP/JGC | JGC |
| | | Unifiner-Platformer | 5,000 bbls | ..... | Engineering | June 1961 | UOP | UOP/JGC | JGC |
| | | Merox | 4,000 bbls | ..... | Engineering | June 1961 | UOP | UOP/JGC | JGC |
| **Daikyo Oil** | **Yokkaichi** | Merox | 6,000 bbls | ..... | Planning | ..... | UOP | UOP/JGC | JGC |
| **Furukawa Chemical Industries** | **Japan** | **Platforming** | **5,000 bbls** | ..... | **Planning** | ..... | **UOP** | **UOP/JGC** | ..... |
| Fuji Iron & Steel | Himeji | Unifining, Udex | 700 bbls | ..... | Engineering | ..... | UOP | UOP/JGC | JGC |
| General Oil | Kawasaki | Merox | 5,700 bbls | ..... | Engineering | Oct 1961 | UOP | UOP/JGC | JGC |
| **Koa Oil** | **Iwakuni** | **Delayed Coker** | **4,500 bbls** | ..... | Under Constr | **1960** | **UOP** | **UOP/JGC** | JGC |
| | | Unifining | ..... | ..... | Planning | ..... | UOP | UOP/JGC | JGC |
| | | Merox | ..... | ..... | Planning | ..... | UOP | UOP/JGC | JGC |
| Kokan Chemical Industries | Kawasaki | Ethylbenzene | 328 bbls | ..... | Engineering | Oct 1961 | UOP | UOP/JGC | JGC |
| | | Styrene Monomer | 13,000 tons/yr | ..... | Engineering | Oct 1961 | UOP | UOP/JGC | JGC |
| | | Udex | 500 bbls | ..... | Complete | ..... | UOP | UOP/JGC | JGC |
| **Kyowa Fermentation Industry Co., Ltd.** | ..... | **Acetaldehyde** | **45 tons** | ..... | **Planning** | ..... | **Knapsack-Grieshelm** | **Uhde** | **Uhde** |
| | **Ube** | **Butanol, Octanol, Acetylene, Ethylene** | ..... | **$13,500,000**<br>**$6,500,000** | **Planning**<br>**Planning** | ..... | ..... | **Ilon-Tears** | **Ilon-Tears** |
| **Maruzen Oil** | **Matsuyama** | Unifiner | 4,000 bbls | ..... | Engineering | ..... | UOP | UOP/JGC | JGC |
| | | Udex | 1,500 bbls | ..... | Engineering | ..... | UOP | UOP/JGC | JGC |
| | Shimotsu | Unifiner-Platformer | 6,000 bbls | ..... | Engineering | ..... | UOP | UOP/JGC | JGC |
| | | Unifiner | 4,500 bbls | ..... | Planning | ..... | UOP | UOP/JGC | JGC |
| Mitsubishi Oil | Mizushima | Merox | 2,000 bbls | ..... | Planning | March 1960 | UOP | UOP/JGC | JGC |
| | | Unifiner | ..... | ..... | Planning | ..... | UOP | UOP/JGC | JGC |
| | | Unifiner-Platformer | 3,600 bbls | ..... | Engineering | July 1961 | UOP | UOP/JGC | JGC |
| Mitsubishi Petrochemical | Yokkaichi | Unifiner-Udex | 1,606 bbls | ..... | Engineering | April 1961 | UOP | UOP/JGC | JGC |
| | | Ethylene | 22,000 tons/yr | ..... | Engineering | June 1961 | S & W | S & W /JGC | JGC |
| **Mitsui Petrochemical Industries** | **Iwakuni City** | Xylene Isomerization | ..... | ..... | Complete | ..... | Atlantic | SD/JGC | JGC |
| Nihon Synthetic Rubber | Yokkaichi | Exp. Petrochemicals | to 45,000 tons/yr | ..... | Under Constr | 1963 | ..... | ..... | ..... |
| Nippon Mining | Mizushima | Unifiner | 2,000 bbls | ..... | Engineering | ..... | UOP | UOP/JGC | JGC |
| | | Unisol | 2,500 bbls | ..... | Engineering | ..... | UOP | UOP/JGC | JGC |
| | | *Cat Reforming | 6,000 bbls | ..... | Under Constr | ..... | ..... | Houdry | Houdry |
| | | *Hydrodesulfurization | 8,000 bbls | ..... | Under Constr | ..... | Houdry | Catalytic/ Niigata | Catalytic/ Niigata |

*First appearance in tabulation.

## CONSTRUCTION BOXSCORE—*Continued*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licenser | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **Nippon Petrochemicals** | **Kawasaki** | **Alkyl Benzene** | **15,000 tons** | **$4,000,000** | **Planning** | **June 1961** | **Cal Research** | ..... | ..... |
| | | Unifiner-Udex | 800 bbls | ..... | Planning | Aug 1961 | UOP | UOP/JGC | UOP/JGC |
| | | Isopropanol<br>Acetone | 6,000 tons/yr<br>6,000 tons/yr | $2,500,000 | Planning | Dec 1960 | Distiller | S & W | ..... |
| Nippon Petroleum Refining | Yokohama | Cat Cracker | 7,500 bbls | ..... | Engineering | June 1961 | UOP | UOP/JGC | JGC |
| **Nilto Chemical Industry** | ..... | **Synthesis Gas** | **125 tons** | **$6,000,000** | **Planning** | ..... | **Texaco** | **Iino-Tears** | **Iino-Tears** |
| Osaka Gas | Osaka | *Catalytic Oil Gasification | 20 MMcf | $1,800,000 | Engineering | Late 1960 | Onia Gegi | H & G | Ishii Iron |
| SBA/Sumitomo Chemical | Niihama City | **Acetylene-Ethylene** | ..... | ..... | **Planning** | ..... | ..... | **Staff** | **Staff** |
| **Showa Denko KK** | **Tokyo** | **Synthesis Gas** | **121 short tons** | ..... | Complete | ..... | **Texaco** | **Foster Wheeler** | **Foster Wheeler** |
| | | *Carbon Black | ..... | ..... | Under Constr | ..... | Phillips | ..... | ..... |
| Showa Oil | Kawasaki | Unifiner-Platformer | 6,000 bbls | ..... | Engineering | Oct 1961 | UOP | UOP/JGC | JGC |
| | | Merox | ..... | ..... | Planning | ..... | UOP | UOP/JGC | JGC |
| Sumitomo Chemical/ SBA | Niihama City | Acetylene-Ethylene | ..... | ..... | Engineering | ..... | SBA | SBA | ..... |
| Toyo Koatsu | Shimonoseki | *Ehanolamines | 150 tons | ..... | Under Constr | July 1960 | Staff/ JGC | Staff/JGC | JGC |
| **Ube Kosan** | ..... | **Ammonia** | **100 tons/day** | ..... | Under Constr | 1960 | ..... | **Chemico** | **Chemico** |
| | | *Ethylene | 21,000 tons/yr | | | | | | |
| | | *Polyethylene | 20,000 tons/yr | ..... | Planning | ..... | ..... | ..... | ..... |
| | | *Polypropylene | 5,000 tons/yr | | | | | | |
| **KOREA** | | | | | | | | | |
| **Korean Government** | **Naju** | **Urea** | **$5,000 tons/yr** | ..... | **Engineering** | **1962** | **Invento** | Lurgi/Uhde | Lurgi/Uhde |
| Korea Petroleum | Ilsan | Refinery | 20,000 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| **MALAYA** | | | | | | | | | |
| Shell of Singapore | Singapore, Malaya Peninsula | Refinery | ..... | $13,300,000 | Planning | ..... | ..... | ..... | ..... |
| Shell of Malaya | ..... | Refinery | ..... | $20,000,000 | Planning | ..... | ..... | ..... | ..... |
| Standard Vacuum | ..... | Refinery, Chemical Fertilizers | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| **SINGAPORE** | | | | | | | | | |
| City Council | ..... | *Catalytic Oil Gasification | 1.5 MMcf | $230,000 | Complete | ..... | Onia Gegi | H & G | H & G |
| Maruzen Oil, Koyo Manka Kaisha | ..... | *Refinery | 20,000 bbls | ..... | Planning | ..... | ..... | ..... | ..... |
| **THAILAND** | | | | | | | | | |
| **Thai Defense Ministry** | **Bangkok** | **Refinery** | **5,000 bbls** | **$20,000,000** | ..... | ..... | ..... | **Japanese Fuji** | **Japanese Fuji** |

## *Australasia*

| COMPANY | Plant Site | Project | Daily Capacity | Estimated Cost | Status | Probable Completion | Licenser | Engineering | Contractor |
|---|---|---|---|---|---|---|---|---|---|
| **AUSTRALIA** | | | | | | | | | |
| **Australian Oil Refining** | **Kurnell** | **Exp. Refinery:** | ..... | ..... | ..... | **1961** | **UOP/ Kellogg** | **Kellogg** | ..... |
| | | Crude | 45,000 bbls | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Cat Cracker | 18,000 bbls | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Alkylation | 3,400 bbls | ..... | ..... | ..... | ..... | ..... | ..... |
| Australian Synthetic Rubber | Altona | Synthetic Rubber | ..... | $10,000,000 | Under Constr | Summer 1961 | ..... | Fluor | Fluor |
| **Bitumen & Oil Refineries** | **Sydney** | **Diesel Unifiner** | **2,500 bbls** | ..... | **Under Constr** | ..... | ..... | **UOP** | **Staff** |
| | | Crude | 12,000 bbls | ..... | Planning | ..... | ..... | Procon | Procon |
| CSRC Dow Pty | Altona | Styrene | ..... | ..... | Under Constr | July 1961 | ..... | ..... | Bechtel/McDonald/Wimpey & Coy |
| Geelong Gas | Geelong | *Refinery Gas Reforming | 3 MMcf | ..... | Engineering | 1961 | Onia Gegi | H & G | H & G |
| **Imperial Chemical Industries of Australia & New Zealand** | Clyde | **Polyethylene** | **5,000 tons/yr** | **$5,040,000** | **Under Constr** | ..... | ..... | ..... | ..... |
| North Thames Gas Board | Romford | *Refinery Gas Reforming | 36 MMcf | ..... | Complete | ..... | Onia Gegi | H & G | H & G |
| **Shell Chemical** | **Clyde** | **Resins, Alkylates** | ..... | **$22,000,000** | **Planning** | ..... | ..... | ..... | ..... |
| | | Cat Cracker | ..... | $38,000,000 | Under Constr | 1963 | ..... | ..... | ..... |
| | | Ethylene | ..... | $22,400,000 | Engineering | Early 1961 | ..... | Braun | Braun |
| **Shell Oil** | **Newport** | **Oil Blending** | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| **Shell Refining** | **Clyde** | **Platformer** | **6,700 bbls** | ..... | Complete | ..... | **UOP** | ..... | **Procon** |
| | | *Cat Cracker | 24,000 bbls | ..... | Planning | Late 1962 | ..... | ..... | ..... |
| **(Australia)** | **Geelong** | **Hydrodesulfuriser** | **11,000 bbls** | ..... | Planning | 1960 | ..... | ..... | ..... |
| | | Detergent Alkylate | ..... | ..... | Complete | ..... | ..... | Foster Wheeler | ..... |
| Southern Gas Board | Portsmouth | *Light Distillate Gasification | 2 MMcf | ..... | Engineering | Late 1960 | Onia Gegi | H & G | H & G |
| **Standard Vacuum** | **Adelaide** | **Refinery** | **30,000 bbls** | **$30,000,000** | **Planning** | **1962** | ..... | ..... | ..... |
| | **Altona** | **Petrochemicals (Ethylene & Butadiene)** | **20,000 tons/yr** | **$28,000,000** | **Engineering** | **Spring 1961** | ..... | **Fluor** | **Utah-Australia** |
| | | *Sulfur Recovery | 40 tons | ..... | Complete | ..... | ..... | Comprimo/ Power-Gas | Power-Gas |
| **Union Carbide** | **Melbourne** | **Polyethylene** | **15,000,000 lbs/yr** | ..... | **Planning** | **1961** | ..... | ..... | ..... |
| **PHILIPPINE ISLANDS** | | | | | | | | | |
| Filoil Refining | Luzon | Refinery | 10,000 bbls | ..... | **Planning** | **Late 1960** | ..... | ..... | ..... |
| **Shell (Philippines)** | **Manila** | **Refinery** | ..... | ..... | Planning | ..... | ..... | ..... | ..... |
| **Standard Vacuum** | **Bataan** | **Refinery** | **25,250 bbls** | **$35,000,000** | **Under Constr** | **Late 1960** | ..... | **Foster Wheeler** | **Foster Wheeler** |

*First appearance in tabulation.

**Atlantic—Atlantic Ref. Co.**
**Austin—The Austin Co.**
**Badger N. V.—Badger N. V., Netherlands**
**Badger Mfg.—Badger Mfg. Co.**
**B & R—Brown & Root, Inc.**
**BASF—Badische Anilin & Sod. Fab.**
**Bechtel—Bechtel Corp.**
**Blaw-Knox—Blaw-Knox Co.**
**Braun—C F Braun Co.**
**Calif. Res.—California Research Corp.**
**Canadian Badger—Canadian Badger Company Limited**
**Canadian Bechtel—Canadian Bechtel Limited**
**Catalytic—Catalytic Construction Co.**
**Chemical Projects Assoc.**
**Chemico—Chemical Construction Co.**
**CTIP—Compagnia Technica Industria Petroli**
**Dresser—Dresser Engineering Corp.**
**Ehrhart—Ehrhart & Associates, Inc.**
**Esso—Esso Research and Engineering Co.**
**Ferguson—H. K. Ferguson Co.**
**Fluor—Fluor Corp.**
**Food—Food Machinery & Chem. Corp.**
**Foster Wheeler—Foster Wheeler Corp.**
**Girdler—Girdler Construction Division, Chemetron Corp.**
**H & G—Humphrey & Glasgow**
**Hudson—Hudson Engineering Corp.**
**Hydrocarbon—Hydrocarbon Research, Inc.**
**HWP—Head Wrightson Process, Ltd.**
**ICI—Imperial Chemicals, Inc.**
**JGC—Japan Gasoline Co.**
**Kellogg—The M. W. Kellogg Co.**
**Kidde Constr.—Walter Kidde Constructors, Inc.**
**Kidde Engrs.—Walter Kidde Engineers Southwest, Inc.**
**Koppers—Koppers Co., Inc.**
**Leonard—Leonard Construction Co.**
**Litwin—Litwin Engineering Co.**
**Lummus—The Lummus Co.**
**Lurgi—Lurgi G. m. b. H.**
**Macco—Macco Corp.**
**McKee—Arthur G. McKee Co.**
**Nefsinger—The C. W. Nefsinger Co.**
**Olsen—O. L. Olsen Co.**
**Parsons—The Ralph M. Parsons Co.**
**Power Gas—Power Gas Corp., Ltd.**
**Pritchard—J. F. Pritchard Co.**
**Procon—Procon, Inc.**
**Quaker—Quaker Valley Constructors**
**S&W—Stone & Webster Engineering Corp., Chemical Division**
**S&W Ltd.—Stone & Webster Canada, Ltd.**
**SBA—Soc. Belge de L'Azote et des Produits Chimiques du Marly**
**SD—Scientific Design**
**SFST—Societe Francais des Services Techniques**
**Soc. Chimique—Societe Chimique de la Grande Paroisse**
**Stearns-Roger—Stearns-Roger Mfg. Co.**
**Sumner Sollitt—Sumner Sollit Co.**
**Swco—Southwestern Engineering Co.**
**Tellepsen—Tellepsen Petro-Chem Constructors**
**Treco—Refinery Engineering Co.**
**Uhde—Friedrich Uhde, G. m. b. H.**
**UOP—Universal Oil Products Co.**
**Vulcan—Vulcan Cincinnati, Inc.**

# CORROSION meets its match in Alcoa aluminum conduit

Here's an electrical rigid conduit that you can install and forget.

Alcoa aluminum conduit solves most corrosion problems in and around chemical plants.

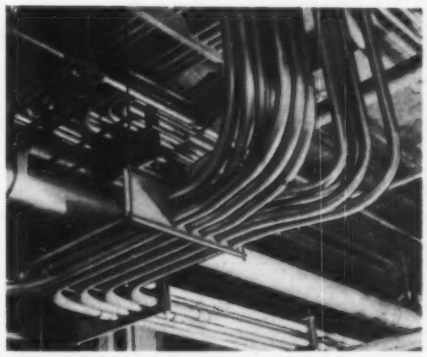
**Aluminum protects itself** Unlike other conduits, which require some kind of coating, aluminum forms its own protective film. This film forms naturally in the atmosphere and in the presence of oxidizing agents. Damaged spots are self-repairing—almost instantly! The natural oxide coating on aluminum takes the place of factory coatings on conventional conduits and only under unusual conditions is any other protection required.

**Other advantages** Corrosion resistance is just one good reason for selecting aluminum conduit. Its light weight (about ⅓ as much as steel) makes it easier to handle and install. Alcoa aluminum conduit is also nonmagnetic and non-sparking.

**How about cost?** Consider initial cost, savings in installation and maintenance, and service life. You'll see that Alcoa aluminum electrical rigid conduit stacks up as a sound investment.

**More information** For specifications, or answers to specific questions about the use of aluminum conduit in corrosive environments, contact one of our nearby representatives. Or write to Rome Cable Division of Alcoa, Dept. 19-70, Rome, New York.

**ROME CABLE**
DIVISION OF **ALCOA**



NO CORROSION despite moisture, chemicals and vapors in the basement of this sewage disposal plant in Cleveland. Installed in 1932, this Alcoa conduit still looks almost like new.

## What's Happening...

# Markets Helped by Improved Demand

**Situation gets better with continued strict control of crude production—cutting of refinery runs**

THE INDUSTRY'S situation improved appreciably during the past month. Prices of gasoline were being generally marked up in the first half of June to more satisfactory levels, in evidence of better market conditions.

Remarkably good demand for petroleum products in May and early June was an important cause of market improvements. Continued strict control of crude production also helped, as did curtailment of refinery runs by numerous companies.

**Demand.** Total demand for all oils in May set a new all-time record for the month, 9.3 percent above May 1959. Virtually all products shared in the increase. The gains included those of 3.1 percent for gasoline, 10.5 percent for distillate fuel oil, 47 percent for kerosine, and 8.2 percent for residual fuel oil.

**First five months.** Aided by the sharp gains of May, petroleum demand for the first five months of 1960 showed better improvement over 1959 than that indicated for cumulatives through earlier months. Total demand for all oils in this year's first five months was 2.5 percent above the like period last year. An even better gain of 3.1 percent was made by the domestic component of demand, as exports were off 20 percent.

For the first five months, increases in demand for major products included those of 1 percent for gasoline, 3.8 percent for distillate fuel oil, 11 percent for kerosine, and 4/10 of 1 percent for residual fuel oil.

**Supply.** Helping to improve the industry's situation again in May was continued strict curtailment of crude oil production, to a level 5.7 percent under May 1959. This made it possible for total new supply to be held 1.6 percent under May last year.

However, other segments of supply were above last year and partially canceled the benefit of stringent crude control. Production of natural gas liquids was up 8.3 percent. Total imports were up 12.4 percent, with crude oil receipts up 6.5 percent and product imports 22.6 percent higher.

Crude runs to stills were held at virtually the same levels in May as in April, averaging 7,930,000 barrels daily, as refiners generally held down throughput to combat surpluses.

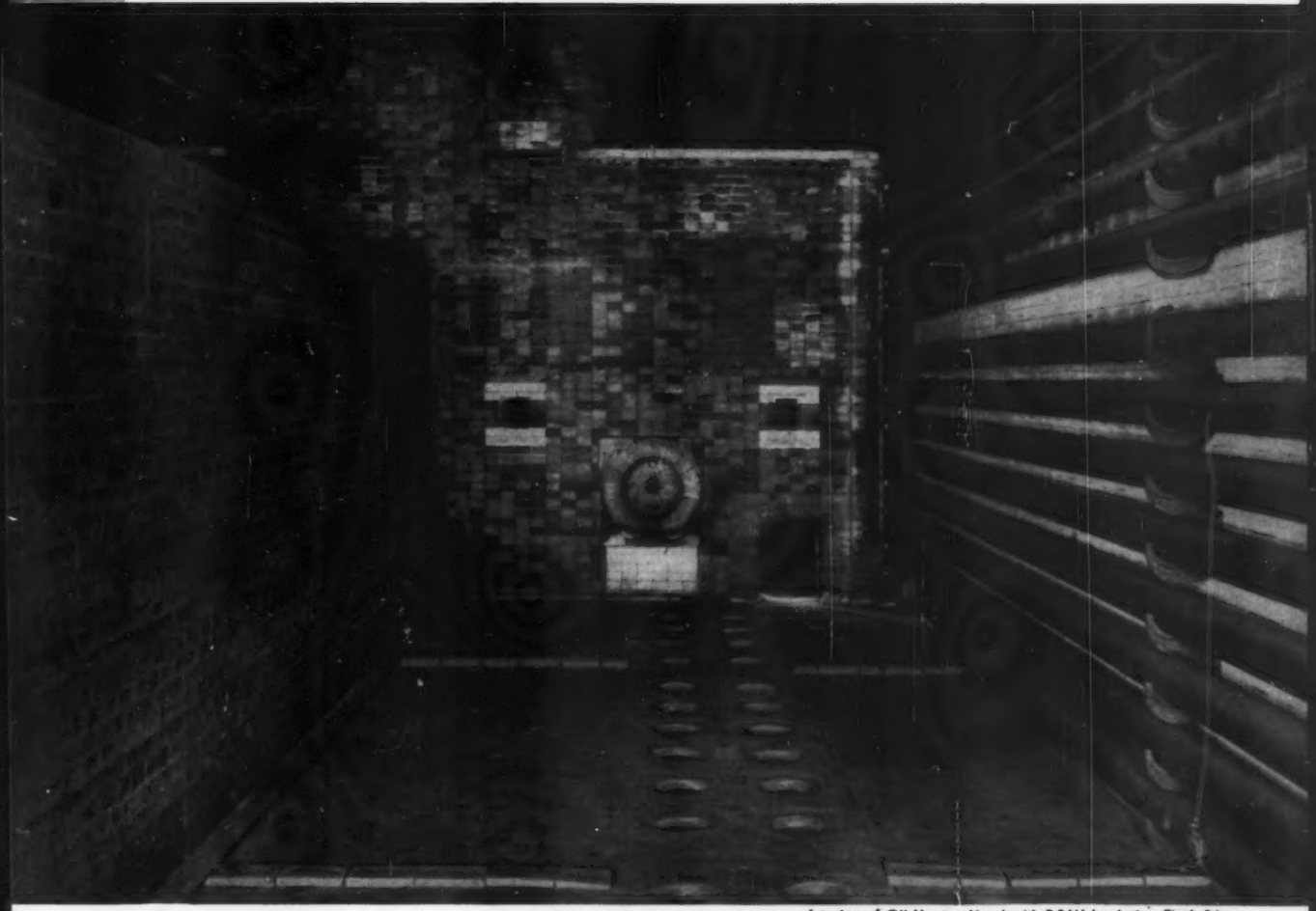
**Stocks.** The net result of operations in May was the avoidance of a large buildup of stocks such as that of May last year. Stocks of all oils showed an increase of only 132,000 barrels daily, in favorable contrast with additions

**U.S. Petroleum Demand and Supply (Thous. Bbls. Daily)**

| ITEM | MAY 1960 | MAY 1959 | MAY % Diff. | April 1960 | JANUARY-MAY 1960 | JANUARY-MAY 1959 | JANUARY-MAY % Diff. |
|---|---|---|---|---|---|---|---|
| DEMAND | | | | | | | |
| All Oils, Total Demand | 9,274 | 8,483 | + 9.3 | 9,249 | 10,183 | 9,932 | + 2.5 |
| Domestic Demand | 9,074 | 8,247 | +10.0 | 9,049 | 9,982 | 9,681 | + 3.1 |
| Export Demand | 200 | 236 | —15.3 | 200 | 201 | 251 | —19.9 |
| Gasoline, Total Demand | 4,290 | 4,163 | + 3.1 | 4,251 | 3,976 | 3,935 | + 1.0 |
| Distillate, Total Demand | 1,376 | 1,245 | +10.5 | 1,592 | 2,234 | 2,153 | + 3.8 |
| Kerosine, Total Demand | 191 | 130 | +46.9 | 239 | 382 | 344 | +11.0 |
| Residual, Total Demand | 1,386 | 1,281 | + 8.2 | 1,734 | 1,831 | 1,824 | + 0.4 |
| Other Oils, Total Demand | 2,031 | 1,664 | +22.1 | 1,433 | 1,760 | 1,676 | + 5.0 |
| CHANGE IN STOCKS | | | | | | | |
| All Oil, Change in Stocks | +132 | +1,078 | ..... | +613 | —268 | + 64 | ..... |
| NEW SUPPLY | | | | | | | |
| Total New Supply | 9,406 | 9,562 | — 1.6 | 9,862 | 9,915 | 9,997 | — 0.8 |
| Domestic Production, Total | 7,739 | 8,078 | — 4.2 | 7,923 | 8,023 | 8,090 | — 0.8 |
| Crude Oil | 6,809 | 7,219 | — 5.7 | 6,998 | 7,080 | 7,216 | — 1.9 |
| Natural Gas Liquids | 930 | 859 | + 8.3 | 925 | 943 | 874 | + 7.9 |
| Imports, Total | 1,667 | 1,483 | +12.4 | 1,939 | 1,892 | 1,907 | — 0.8 |
| Refined Products | 668 | 545 | +22.6 | 856 | 898 | 996 | — 9.8 |
| Crude Oil, Total | 999 | 938 | + 6.5 | 1,083 | 994 | 911 | + 9.1 |
| Crude, East of California | 691 | 769 | —10.2 | 812 | 741 | 720 | + 2.9 |
| CRUDE RUNS | | | | | | | |
| Crude Runs to Stills | 7,930 | 7,896 | + 0.4 | 7,950 | 8,028 | 8,065 | — 0.5 |
| Domestic Crude | 6,861 | 7,021 | — 2.3 | 6,986 | 7,040 | 7,160 | — 1.7 |
| Foreign Crude | 1,069 | 875 | +22.2 | 964 | 988 | 905 | + 9.2 |

**U.S Stocks of Oils (Million Bbls. at End of Month)**

| KIND OF OIL | TOTAL IN U.S. May 1960 | TOTAL IN U.S. May 1959 | TOTAL IN U.S. % Diff. | TOTAL IN U.S. April 1960 | EAST OF CALIFORNIA May 1960 | EAST OF CALIFORNIA May 1959 | EAST OF CALIFORNIA % Diff. | EAST OF CALIFORNIA April 1960 |
|---|---|---|---|---|---|---|---|---|
| All Oils | 773.1 | 795.4 | — 2.8 | 769.0 | ..... | ..... | ..... | ..... |
| Crude Oil | 259.5 | 264.5 | — 1.9 | 262.7 | 225.9 | 227.5 | — 1.7 | 229.2 |
| Gasoline | 210.9 | 205.6 | + 2.6 | 219.3 | 178.8 | 175.3 | + 2.0 | 187.3 |
| Distillate Fuel Oil | 93.5 | 101.8 | — 8.2 | 82.0 | 82.1 | 89.6 | — 8.4 | 70.6 |
| Kerosine | 24.7 | 24.5 | + 0.8 | 20.4 | 22.9 | 24.1 | — 5.0 | 19.1 |
| Residual Fuel | 39.9 | 54.0 | —26.1 | 39.1 | 27.0 | 26.7 | + 1.1 | 25.5 |
| Other Oils | 144.6 | 145.0 | — 0.3 | 145.5 | ..... | ..... | ..... | ..... |



Interior of Oil Heater Lined with B&W Insulating Firebrick.

# B&W Refractories stay on stream

Long refractory life, low furnace maintenance, and dependable service result from the use of B&W Refractories. B&W offers a wide line of *specialized* refractories *engineered* to give you maximum furnace availability and economy.

Naturally, the refractory selected depends on the specific service. B&W Insulating Firebrick, for example, serve a dual role. First, these durable, lightweight IFB are most efficient insulators, and second, they withstand direct exposure to furnace heat. This means . . .

REDUCED CONSTRUCTION COSTS—The lightweight and high insulating value of B&W IFB combine to lower material costs and simplify furnace design. Because they withstand furnace heat, they eliminate the need for dense refractory constructions backed up with insulating materials. This, together with lightweight, means thinner, lighter wall constructions, often providing savings in structural steel and foundation costs.

REDUCED OPERATING COSTS—The high insulating value of B&W IFB means savings in everyday operation. Per inch of thickness, B&W IFB provide more insulation than any other refractory lining. Less heat is lost, casing temperatures are lower, working conditions are improved and efficiency is increased.

Furthermore, since B&W IFB are light in weight, they store and conduct less heat. Heavy refractories retain heat; in the event of forced shutdown, they can cause burn-out of expensive alloy tubes, where used. The low quantity of heat stored by B&W IFB can be quickly dissipated, thus protecting these expensive tubes.

This low heat storage also permits faster heating and cooling. This means quicker access to the furnace in the event of emergency shutdown. Your maintenance crew can get in the furnace sooner and get it back on stream faster.

Consult your B&W Refractories Representative for assistance with your refractories problem or write to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

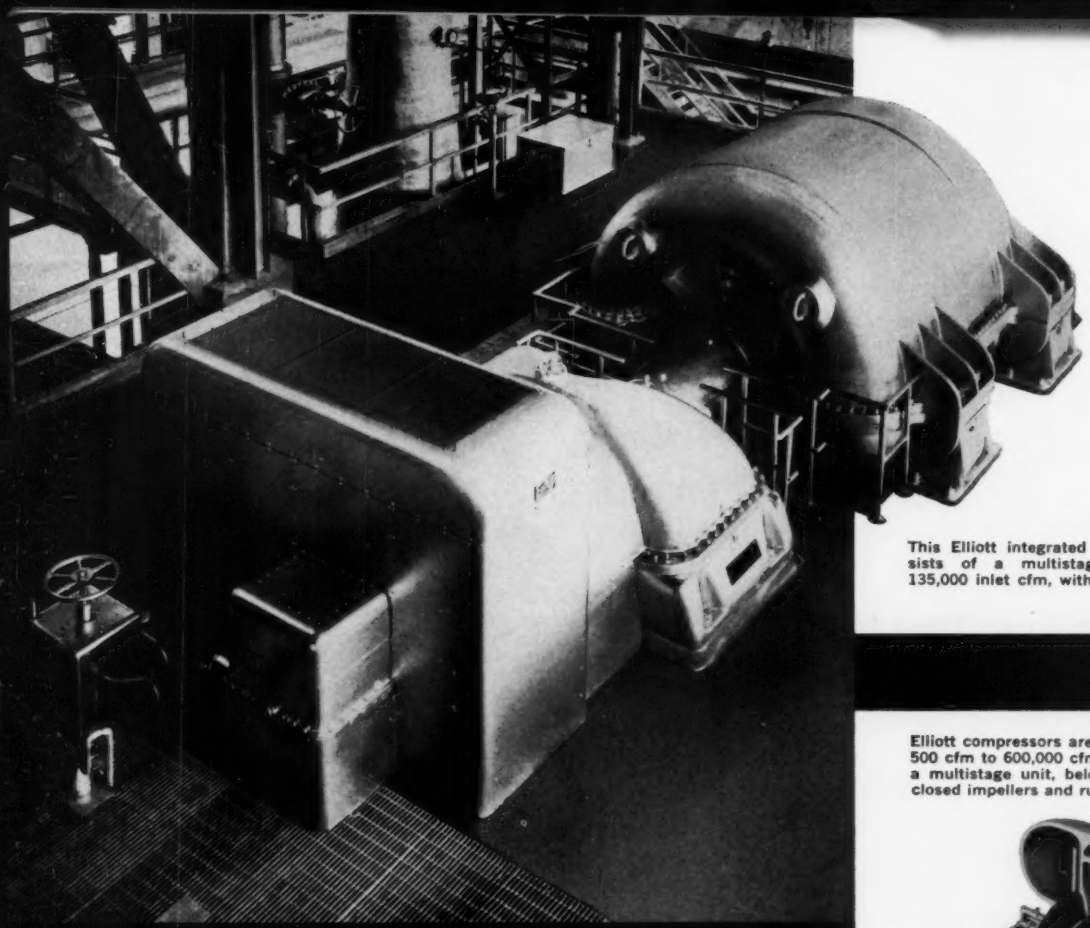
B&W

THE BABCOCK & WILCOX COMPANY

***REFRACTORIES DIVISION***

R-628

**B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.**



This Elliott integrated compressor unit consists of a multistage compressor rated 135,000 inlet cfm, with its 12,440-hp turbine.

Elliott compressors are made in capacities of 500 cfm to 600,000 cfm. The cutaway view of a multistage unit, below, shows the welded, closed impellers and rugged casing.

# Demands of large FCC unit prove excellence of

# Elliott Turbine-Compressor

For over six years, the machine shown above has kept things moving through a 40,000-barrel-per-day fluid catalytic cracking unit in Texas. Said to be the largest of its kind when installed in 1953, it serves the catalyst circulating and regenerating system of the refinery unit as efficiently today as it did the day it was installed.

Elliott offers the most complete line of well-established centrifugal and axial flow compressors for gas and air—with matching Elliott motor or turbine drives. There are 48 compressor frame sizes, providing excellent choice for all applications over the entire range of capacities from 500 cfm to 600,000 cfm.

Since the drive represents half of any compressor installation, the unified design inherent in these driver-compressor combinations assures greatest satisfaction. Elliott turbines and motors are made in a wide range of sizes, types and ratings, assuring ample choice for all applications.

For further information, consult nearest Elliott office, or Compressor Department, Elliott Co., Jeannette, Penna.

**ELLIOTT** THE MOST COMPLETE LINE OF **INTEGRATED COMPRESSOR & DRIVER UNITS** 500 cfm to 600,000 cfm

**ELLIOTT Company**
Jeannette, Penna.

PO-2

averaging 1,078,000 barrels per day in May of last year.

The fact that gasoline prices were advanced during the first half of June was some evidence that gasoline stocks are not seriously excessive. However, they are larger than desirable. It is true that gasoline demand currently is higher than ever before, and that fact helps to justify larger stocks than in the past. But even in relation to demand, gasoline inventories are greater than in other recent years except last year.

Gasoline stocks at the end of May 1960 were equivalent to 49.2 days' supply at the May rate of demand, compared with 49.4 days' supply in 1959, 47.7 in 1958, 47.3 in 1957, 45.6 in 1956, 44.1 in 1955, 51.3 in 1954, 44.5 in 1953, 37.8 in 1952, 40.0 in 1951, 41.1 in 1950.

Those figures indicate that gasoline stocks of 40 to 45 days' supply on May 31 would be adequate. Instead of 211 million barrels held May 31, 1960, requirements were only 172 to 193 million, or 18 to 39 million less than were held. Averaging those extremes it may be said conservatively that gasoline stocks are too high by about 30 million barrels.

## Ten-Percent Increase in Lube Grease Production

Production of lubricating greases increased almost ten percent in the United States during 1959, over 1958 production. Members of the National Lubricating Grease Institute received their third annual production survey with this information on April 18. Fluid gear lubricant production also showed a gain last year.

The NLGI survey collects data on six soap types and on total fluid gear lubricant production. Because an estimated 95 percent of the industry belongs to the Institute, the 78 percent of manufacturers replying to the survey give what has been generally accepted as an 85 percent of actual lubricating grease production in the United States. Six major Canadian manufacturers have also been participating for the past two years.

## Says Gas Turbine Engine To Lead Within Six Years

Gas turbine engines may surpass piston engines in automobiles within six years from the standpoint of engineering and cost, according to Chrysler Corp. researcher G. J. Huebner, Jr. Within this period, he said, the turbine engine will "be able to do almost anything that can be done with the piston engine, and can add to customer convenience and satisfaction by providing many advantages which the piston engine cannot provide."

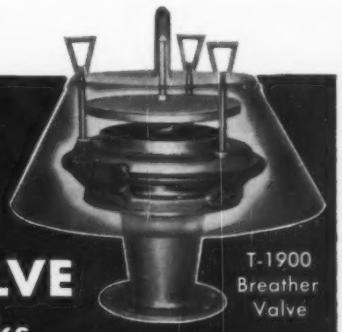
## Predict That Consumption Of Petroleum Wax to Grow

Consumption of petroleum wax will continue to grow in the years to come despite some predictions to the contrary, a session of NPA's 57th Mid-Year Meeting was told recently. K. S. Canfield and A. C. Smith Jr., of The Atlantic Refining Co., said in a paper they were convinced that not only would wax consumption in present uses expand, but new uses would be found.

In another paper, Morris W. Kane of Sutherland Paper Co., said waxes of the future should be rated for their ability to make paper resist penetration of water or vapor, for their heat sealing and laminating properties, for the quality gloss they give wax paper and for such undesirable properties as scuffing, staining and blocking.

R. W. Dannenbrink and G. Eugene Unmuth, of American Can Co., discussing polyethylene additives in another paper, said the best way to obtain a desired set of physical characteristics from a finished blend of wax is to select a wax which has a balance of properties nearest those required and add the particular polyethylene which will result in improvement of the most critical requirements.


NEW
Wheaton
BREATHER VALVE
gives storage tanks
MAXIMUM FLOW and
MINIMUM VAPOR LOSS


T-1900 Breather Valve

**This new Wheaton Type T-1900 "Quality Built" Breather Valve** is thoroughly lab-tested and field tested for high flow rate and vapor tight control of vacuum and pressure.

Big advantages include diaphragms for both pressure and vacuum pallets . . . anodized aluminum bodies . . . large areas of flow spaces . . . easy inspection and maintenance.

The Wheaton Type T-1900 Breather Valve can help *your* storage tank operation. Send for details now.

**GET TIGHT, PRECISION EMERGENCY VENTING**

For emergency venting of storage tanks, use the *Wheaton Type T-1950 Emergency Vent and Manhole Cover*. As required in A. P. I. Venting Guide, a diaphragm seal in cover assures positive seating.

**WHEATON BRASS WORKS, UNION, N. J.**

*Manufacturers of Loading Arm Assemblies, Swing Joints, Loading Valves, Storage Tank Fittings and Truck Tank Equipment for the Petroleum and Chemical Industries.*

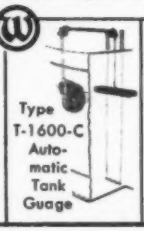
**Foreign Manufacturers**

Emco Ltd., London, Ontario, Canada • Emco Brass Mfg. Co. Ltd., Margate, Kent, England
Emco G.M.B.H., Allendorf, Germany • Ljungmans, Malmo, Sweden
Baza S.R.L., Buenos Aires, Argentina, S.A.

**Install WHEATON fittings on your storage tanks**

Type T-1550 Water Drain Valve

Type T-1600 Automatic Tank Gauge


Type T-1600-C Automatic Tank Guage

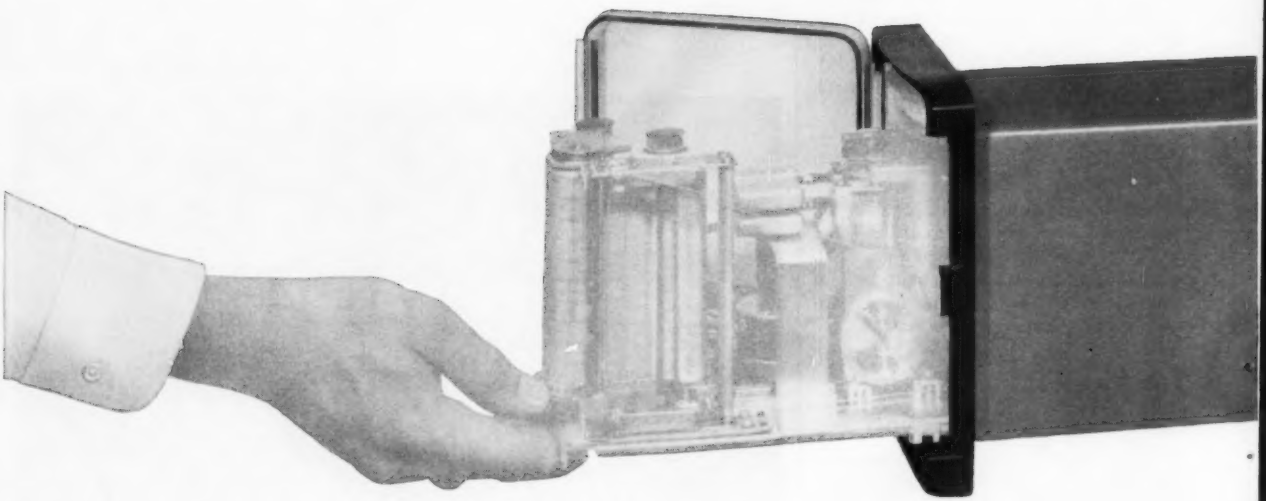
Type T-1695 Midpoint Thermometer

Type T-1700 Gauge Hatch




For more data on advertised products, use Readers' Service Cards, last page.

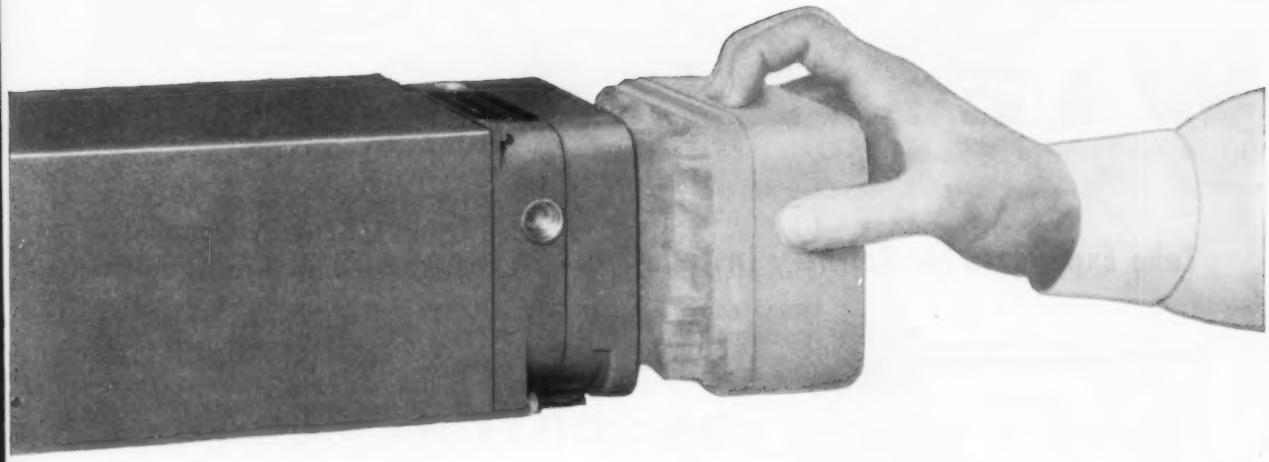
# NEED THE BEST MINIATURE



*Now we can give you 2 to 4 weeks delivery on TRANSCOPE® pneumatic and electronic recorder housings*

*Taylor Instruments*

# RECORDERS IN A HURRY?



Ready for instrumentation—but no instruments? Here is good news! We will ship you TRANSCOPE housings with manifolds within 2-4 weeks of receipt of your order. The unique plug-in features of the 90J pneumatic and 700J electronic recorders and TRANSCOPE controllers enable you to install these housings and make all necessary connections to the tagged manifolds while we complete manufacture of the instruments. You will then be ready to plug in recorders on delivery—approximately 4-6 weeks later—and be on stream immediately.

Now your expansion or modernization plans need not be crippled by the current long deliveries prevalent in the instrument industry. Take advantage of the exclusive design features of these Taylor miniature recorders and be on stream up to 6 weeks sooner than otherwise possible.

**How is this possible?** The same features that enable us to ship the housings early permit our Production Department to build up a reserve stock of separate housings and built-in manifolds. Two shifts daily, including Saturdays, assure fulfilment of this delivery schedule.

Call your Taylor Field Engineer for the complete story on the TRANSCOPE line—the hottest instruments on the market today! Or write for **Bulletins 98286** (pneumatic), and **98335** (electronic). Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ont.

## *MEAN ACCURACY FIRST*



For more data on advertised products, use Readers' Service Cards, last page.

## *Happenings . . .*

### World-Wide Oil Surplus May Be Blessing, Says Exec

The world-wide oil surplus contains "some blessings in disguise," Henderson Supplee, Jr., president of The Atlantic Refining Co. told stockholders at the company's recent annual meeting. Referring to the present oversupply, Supplee said, "A completely new insurance factor has been brought into the previously too flammable international petroleum atmosphere." Because of the present surpluses, he explained, there is more assurance of uninterrupted supply of petroleum products than the world has known since the days of the East Texas boom in the early nineteen-thirties.

"In recent years," Supplee pointed out, "American consumers, as they became more dependent on supplemental foreign production, were vulnerable to politically motivated actions that could have reduced or shut off supply from any important producing country. Such action today would so directly benefit competing countries that it would be economically suicidal."

Acknowledging that the supply of crude oil and oil products has moved ahead of demand, Supplee emphasized, however, that demand is not lacking. "Throughout the world," he said, "there is respectful recognition of petroleum as a vitally precious asset. Hence, there is no disposition to waste it or to throw it on the market at distressed prices."

Supplee cited the very effective controls of both conservation and economy nature. "In this country," he said, "state commissions have imposed severe limitations on crude production. This is supplemented by U.S. oil import policy; and abroad, every producing country imposes exploitation terms that exert economic pressures against low-priced disposal."

Supplee reported that Atlantic is undertaking a comprehensive program of adjusting its operations to meet new conditions brought about by the surplus of oil.

### Looks for Energy Demand To Overcome Price Problem

Gigantic energy demands in the next decade will overcome the present chaos of petroleum-energy price problems, said President Paul Kayser, Western Natural Gas Corp., at a recent stockholders meeting. He said global economic revolution will bring back all energy at a level high enough price-wise for the petroleum industry to stay in business. Rapid overseas developments in energy uses will correct current industry imbalances, he added. Kayser said the mandatory import control program is "a step in the right direction." He felt that the industry would be demoralized for an extended period should the governments allow uncontrolled imports of foreign oil.

### Socony Mobil Prexy Says Competition Has Shifted

The competitive emphasis in the oil industry has shifted in recent years from concentration mainly on supply to the question of who can operate most efficiently, President Albert L. Nickerson, of Socony Mobil Oil Co., Inc., said in a recent talk to API's Division of Finance and Accounting. He labeled cost control "one of the most promising and fertile" fields for improvement of profits.

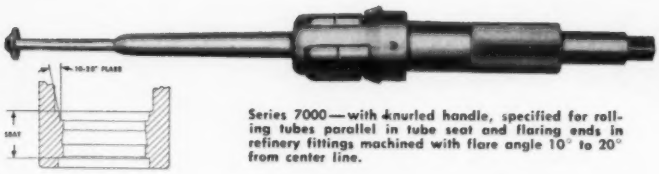
"Widespread development of cost consciousness and the achievement of lower operating costs," he asserted, "could, in these Spartan days, be almost as vital to management as efficient accounting itself." Nickerson stressed four prime requirements in the preparation and presentation of financial data to top management:

- Easily digestible information, and all of it relevant to the specific problem at hand.
- Timeliness: "What would be worth a million dollars if known today, may be only an interesting historical fact tomorrow."
- "Responsibility accounting": Present-

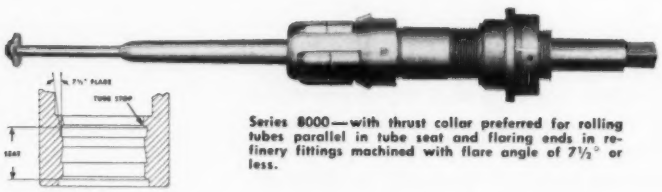

WIEDEKE

THE QUALITY NAME IN TUBE EXPANDERS . . . SINCE 1892

Tube Expanders for Refinery Installations



Series 7000—with knurled handle, specified for rolling tubes parallel in tube seat and flaring ends in refinery fittings machined with flare angle 10° to 20° from center line.



Series 8000—with thrust collar preferred for rolling tubes parallel in tube seat and flaring ends in refinery fittings machined with flare angle of 7½° or less.

Series 9000—with thrust collar, used for rolling tubes parallel in tube seat of refinery fittings with tube stop, no flare.

#39

IDEAL

Specialization since 1892 in the manufacture of Tube Expanders, Tube Cutters and Operating Accessories provide the right answers to your tube installation and maintenance problems. Write for our *new* General Catalog 81.

The Gustav WIEDEKE Company

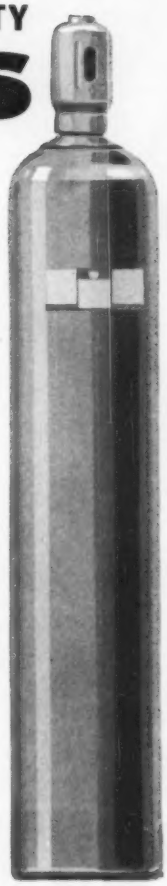
DAYTON 1, OHIO

# HARSHAW

## PRODUCTION CONTROLLED HIGH-QUALITY

# FLUORIDES

## BORON TRIFLUORIDE
## HYDROFLUORIC ACID
## ANHYDROUS . . . AQUEOUS



Shipments of Fluorides roll out of our Cleveland plant daily, either in tank cars, tube trailers, or in cylinders. Each shipment incorporates the knowledge gained during more than 45 years as a major producer of Hydrofluoric Acid.

We offer you the benefit of our accumulated experiences in engineering problems involving corrosion, safe handling and storage facilities.

**Write for your free copy of M.C.A. Chemical Safety Data Sheet SD-25 on properties and essential information about . . . HYDROFLUORIC ACID Anhydrous and Aqueous.**

**THE HARSHAW CHEMICAL CO.**
1945 East 97th Street • Cleveland 6, Ohio

Chicago • Cincinnati • Cleveland • Detroit • Houston
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**Harshaw Also Supplies:**

Ammonium Bifluoride
Ammonium Fluoborate
Barium Fluoride
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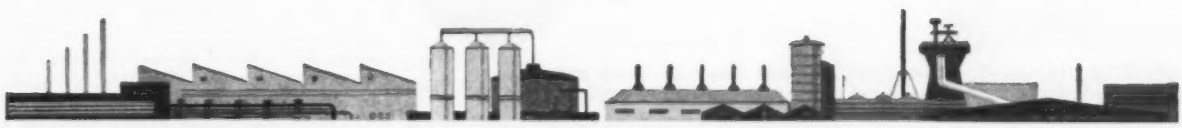
Boron Trifluoride Complexes
Chromium Fluoride
Copper Fluoborate
Fluoboric Acid
Fluorinating Agents
Frosting Mixtures
Hydrofluoric Acid Anhydrous
Hydrofluoric Acid Aqueous
Hydrofluosilicic Acid
Laboratory Fluorine Cells
Lead Fluoborate
Lithium Fluoride
Metallic Fluoborates
Potassium Bifluoride
Potassium Chromium Fluoride
Potassium Fluoborate
Potassium Fluoride
Potassium Titanium Fluoride
Silico Fluorides
Silicon Tetrafluoride
Sodium Fluoborate
Tin Fluoborate
Zinc Fluoborate
Zinc Fluoride

HARSHAW





For more data on advertised products, use Readers' Service Cards, last page.

ing information to management in terms that correspond with individual responsibilities in the organization.

• Establishment of standards of cost control, to identify controllable costs and to set standards before money is committed.

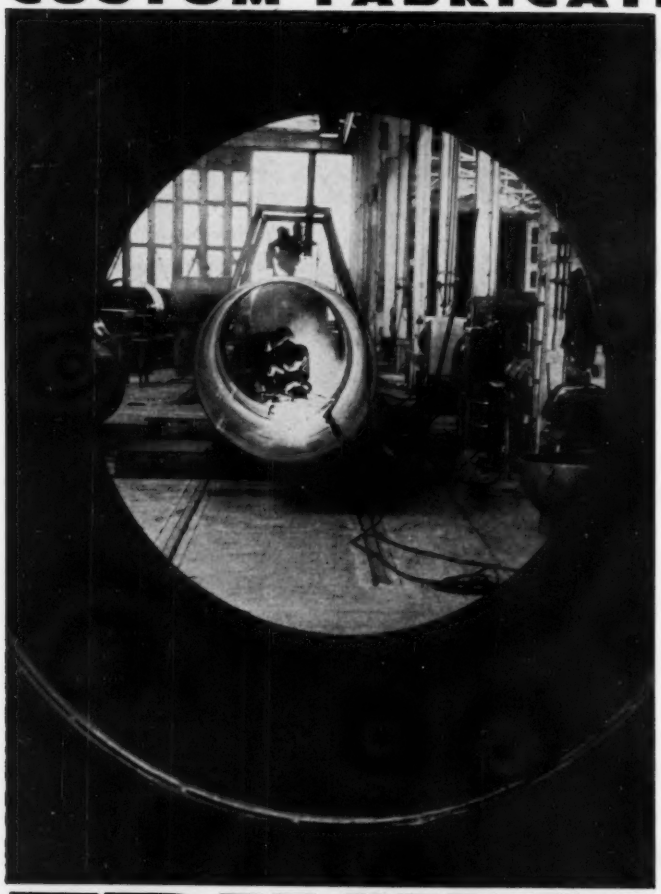
Nickerson also said that, while markets for most oil products are still growing rapidly, the nature of these markets and the availability of supplies has changed. Opportunities to expand markets profitably are going to be relatively scarce during times of small profit margins, he added.

"As attractive opportunities become fewer," he declared, "there will be greater rewards to the company that can first recognize and seize these opportunities."

## Domestic Demand for Oil Up 3.7 Percent From 1959

The Bureau of Mines' estimate of domestic demand for all oils in 1960 is 9.8 million bpd, up 3.7 percent from 1959. The forecast incorporates actual first-quarter figures and API data for April and May. Crude production is expected to average 7.1 million bpd, up 1.5 percent over 1959. Production of natural gas liquids, however, is expected to rise 4.8 percent over 1959. For July, domestic crude demand is expected to be 7 million bpd, compared with 6.9 million bpd predicted for June. The July forecast included estimates of total gasoline demand of 4.6 million bpd, gasoline yield of 46.2 percent, and total crude runs of 7.9 million bpd.

CUSTOM FABRICATION



COMPLETE ENGINEERING FACILITIES
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ALL STEELS
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ALL CODES
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PROCESS TOWERS FOR THE REFINERY & CHEMICAL INDUSTRY
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PRESSURE VESSELS
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REFINERY TANKS
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UTILITY PETROLEUM VESSELS
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REACTOR VESSELS

TRINITY
STEEL COMPANY, INC

TRINITY STEEL

4001 IRVING BLVD.—DALLAS, TEX.—FL 7-3981. LATIN AMERICAN DIVISION: TANQUES DE ACERO TRINITY S. A., CALLE PONIENTE 150, #734, MEXICO 16, D. F. PLANT AND SALES OFFICE. PLANTS IN: DALLAS, TEXAS; FRANCESVILLE, INDIANA; MEXICO CITY, D. F.

## Venezuela's Perez Would Discuss Prorationing

Venezuelan oil minister Juan Perez Alfonzo said he "would be interested in talking with USSR oil policy planners" about a proposed international prorationing compact. He said Venezuela hasn't taken any concrete steps toward talks with the Soviets, but said "it is convenient to consider whether the moment has arrived for Russia to set forth its intentions with respect to the international market." He added: "If Russia plans to export oil on a permanent basis, we who are interested in the compact should know what is contemplated in the Russian program . . . The proposed compact embodies the principle that permanent net exporters should have a hearing in order to determine whether they should be included in the agreement. Up to now, it isn't clear whether the Soviet Union could have consumed domestically the oil it exported, were it not for exceptional circumstances."

## Says No Monopoly Planned By Big French Company

French minister of industry and commerce Jean-Marie Jeanneney says that government-controlled Sahara producers are expected to get a foot-hold in France through a new state-controlled refining and marketing company, but that the government doesn't plan to create an oil monopoly. The firm, Union Generale des Petroles, was set up to help solve the problem of marketing Sahara crude in face of world overproduction and the prospect of Soviet cut-rate offerings, Jeanneney said. Backed by a refining-marketing network, Sahara producers will be able to market their output under better conditions, he added.

## NCA Protests April Upping Of Resid Allocation Level

A protest to the April 9 increase in residual fuel oil import allocation levels has been sent to Interior Secretary Seaton by Stephen F. Dunn, president of National Coal Association. He charged that the Bureau of Mines disregarded "the spirit of President Eisenhower's order by allowing estimates of consumer demand for foreign residual oil to be raised arbitrarily to reflect additional business which oil importers get by price-cut raids on domestic fuel markets."

## Trade Associations Ask For ASA Thermocouple Project

To aid in the manufacture and simplify the use of thermocouples and thermocouple extension wires, the establishment of an ASA project on thermocouples has been recommended. The move was made by representatives of 16 national trade



For more data on advertised products, use Readers' Service Cards, last page.

**THERE'S NO STUFFING BOX** to adjust or repack on LIGHTNIN Mixers in this butadiene extraction unit at the Orange, Texas plant of The Firestone Tire & Rubber Company. These LIGHTNINs are equipped with easily replaceable mechanical seals.

# *How to keep a solvent extraction train* highballing

A crucial problem facing the engineers who designed this butadiene solvent-extraction train was: how to *keep* it continuous.

In these nine tanks, mechanical mixers were needed to provide intimate contact between the solvent phase and the hydrocarbon phase for quick and complete recovery of butadiene.

But where was a proved mixer design that would keep running for years—without frequent short stoppages for repacking, or costly dismantling in case of a shaft seal failure?

They found the answer in the LIGHTNIN Mixers you see here.

These LIGHTNINs never have to be repacked. Each is equipped with a *mechanical shaft seal that positively prevents leakage*—and runs, not for months, but for *years* without ever needing adjustment.

### New shaft seal—in a hurry

Best of all, seal replacement is a fast, simple job.

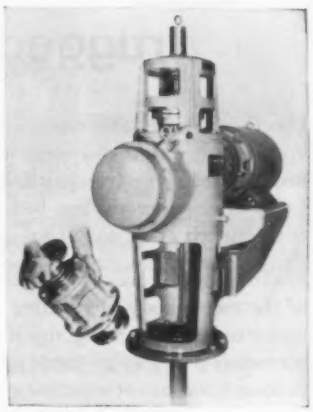
When a seal eventually does wear out, it can be replaced quickly. There's no need to dismantle the mixer or take it off the tank. No need for highly trained personnel, either; any man who can handle a wrench can replace the LIGHTNIN seal.

He merely unbolts two couplings; takes out the seal cartridge as one piece; couples in a new cartridge. Mixer shaft alignment is built-in—need not be checked.

If you're mixing corrosive chemicals under pressure or vacuum, you may save many thousands of maintenance dollars by specifying Series "E" LIGHTNIN Mixers with these quick-change mechanical seals.

You can get LIGHTNINs in hundreds of power-speed combinations, for tanks of any size or shape. Performance is unconditionally guaranteed.

For the full story on increased productivity you get and long-term maintenance savings you make with seal-equipped LIGHTNIN Mixers, call in your LIGHTNIN representative. He's listed in Chemical Engineering Catalog. Or write us direct.



**CARTRIDGE SEAL** runs for years without adjustment . . . and uncouples for rapid replacement.

☐ *Quick! Send us the cost-cutting facts on LIGHTNIN Rotary Mechanical Seals—Bulletin B-111. We'd also like catalog information on these LIGHTNIN Mixers:*

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering propeller type: ¼ to 3 HP (B-103)
- ☐ Side entering; 1 to 25 HP (B-104)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Data sheet for figuring mixer requirements (B-107)

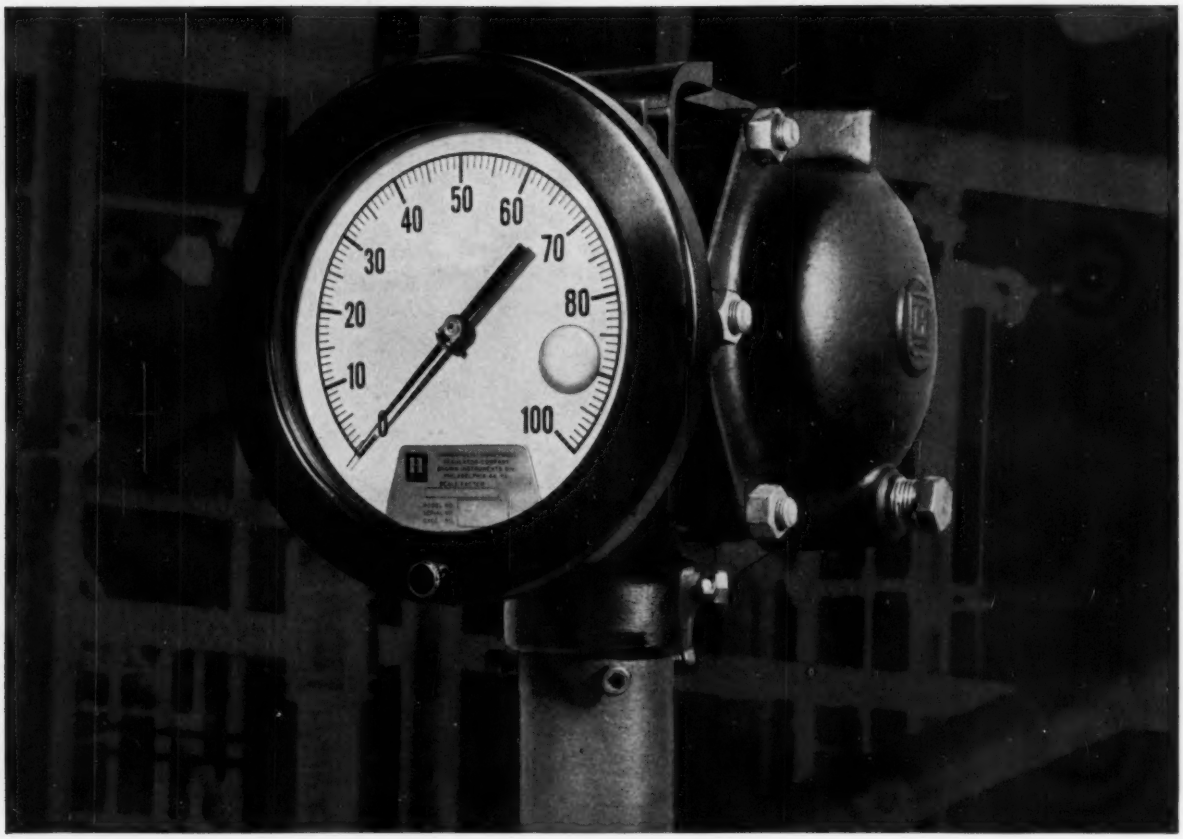
*Check, clip, and mail with your name, title, company address to:*

**MIXING EQUIPMENT CO., Inc., 164-g Mt. Read Blvd., Rochester 3, N. Y.**

*In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 19, Ont.*

**Lightnin® Mixers**

**MIXCO fluid mixing specialists**




# New indicating bellows meter is accurate, rugged and safe in any atmosphere

Use this new bellows meter for any flow or liquid level application where you want local indication, but don't need recording or transmission. It combines the advantages of the mercuryless bellows meter body with the convenience of an easy-to-read 6-inch dial indicator.

Make pressure connections from either the top or bottom of the meter body, depending on whether you want the meter to be self-venting, draining or purging. And forget corrosion worries; all parts of the bellows exposed to process fluids are of seamless stainless steel construction.

This rugged meter will perform accurately in the toughest service. Two meter bodies are available with pressure ratings of 1000 and 2500 psi, tested at 1500 and 4000 psi respectively. And you can use the meter in hazardous atmospheres because it is self-powered . . . at any ambient temperature between −40° and +250°F. In the indicating movement, a stainless steel pointer pinion and a nylon-faced gear sector assure long life and sustained calibration accuracy of ±1% full scale (ranges of 0-50 inches of water and above) and ±1¼% full scale (ranges below 0-50 inches of water).

This new bellows meter has many other features . . . ease of calibration, simple range change, automatic ambient temperature and static pressure compensation, to name a few. Your nearby Honeywell field engineer can give you complete details. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

75th YEAR
PIONEERING THE FUTURE

**Honeywell**

H HONEYWELL First in Control
SINCE 1885

associations, technical societies, and industry at a recent ASA general conference.

The tentative scope for the proposed project is: Requirements for temperature measurement thermocouples including (but not limited to) terminology, fabrication, procedures for ascertaining accuracy, limits of error, wire sizes, installation, color code for thermocouples and thermocouple extension wire, and temperature tables.

## NCA Transfer Headquarters To District of Columbia

Transfer of its headquarters to Washington has been announced by the National Constructors Association. The association, formed in 1946, had maintained offices in New York before the move. New headquarters are in the Continental Building, 1012 14th St. N. W. NCA President D. W. Darnell, board chairman of Fluor Corp., Ltd., Los Angeles, said the new location will better serve some of the principal interests and activities of the association.

## MPSA Says Import Controls Cost U.S. Millions in 1959

Since the start of mandatory import controls in March 1959, the government has paid $9.8 million more for petroleum products than it would have paid without controls, according to the Military Petroleum Supply Agency. The figure was revealed in a recent House Military Operations Subcommittee hearing. It is based on a continuing tally by MPSA showing the difference between domestic and foreign prices for delivered products, less MPSA's own import allocations.

## Petrochemicals Are Eyed By Pakistan for the Future

Petrochemicals are being eyed by Pakistan. The government has received from a West German technical mission a preliminary report on development of a petrochemicals industry based on natural gas production in Pakistan. Gas reserves there, says the report, are sufficient to sustain a petrochemical industry as an economic proposition. Recommended were plants for natural gasoline, acetylene, acrylonitrile, polyvinylchloride, methyl metacrylate, and synthetic fibers.

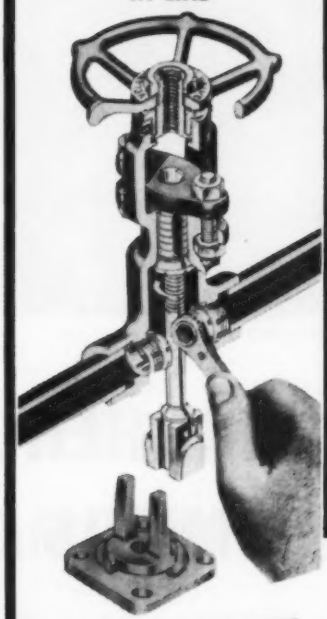
## Residual Fuel Imports to Be Down July-September

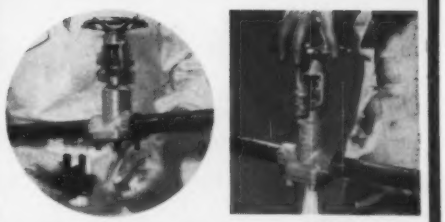
There will be a sharply-reduced level for residual fuel oil imports in the July-September quarter. The new level will


SPECIFY: VELAN BONNETLESS FORGED STEEL GATE VALVES

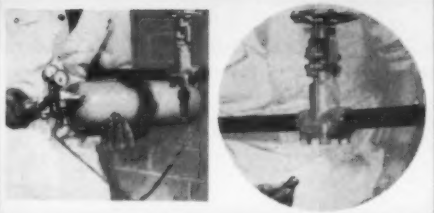
*Patented U.S. 2,905,192

FULLY SERVICEABLE IN LINE





CLEANED OR FLUSHED IN THE LINE



TESTED FOR TIGHTNESS UNDER PRESSURE OR DURING SHUT-DOWN

SAVE:

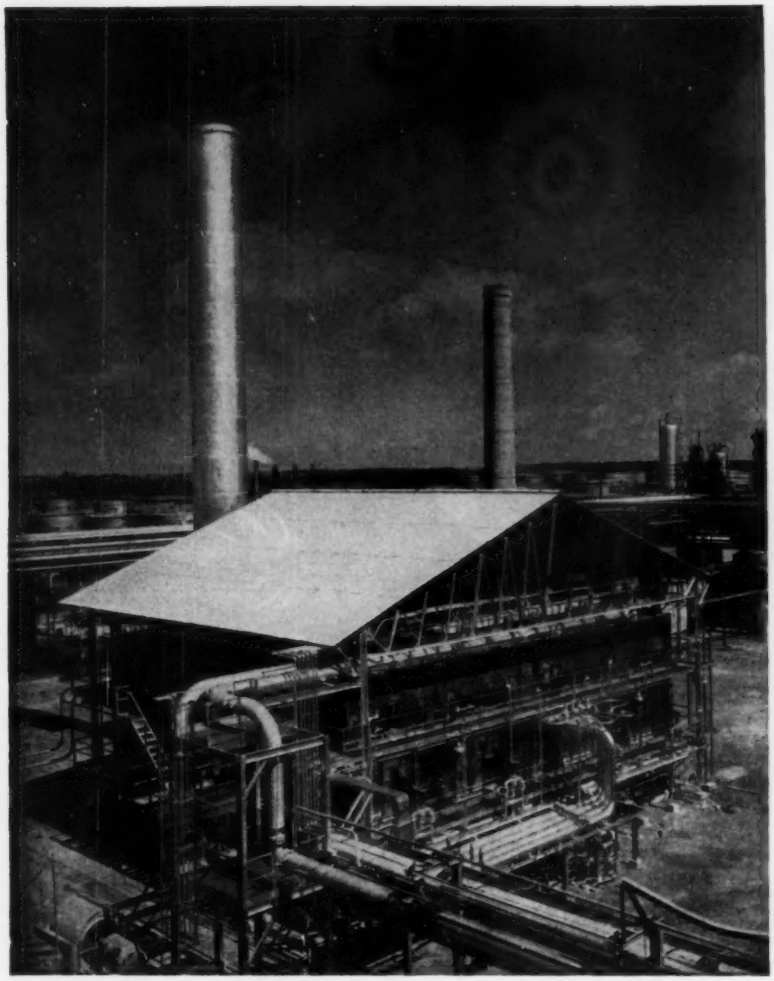
LONG-RANGE COST 70%

MAINTENANCE 50%

U.S.A. AND CANADA—VELAN VALVE CORP.
PLATTSBURG, N.Y., MONTREAL.

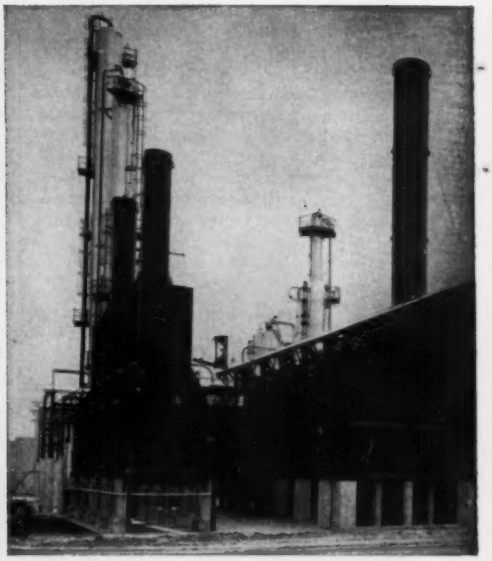
GREAT BRITAIN—NEWMAN, HENDER & CO. LTD.
WOODCHESTER, GLOS.

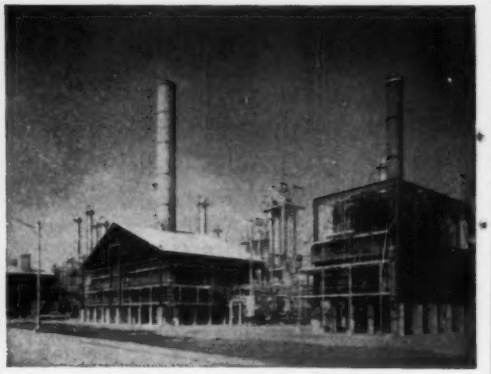
CONTINENTAL EUROPE—RICHARD KLINGER A.G.
GUMPOLDSKIRCHEN, AUSTRIA



Portable crude heater for Magnolia Petroleum Company, Beaumont, Texas.

Ultraformer heater for American Oil Co. at El Dorado, Arkansas.





Platformer and desulphurizer heaters for Shell Oil Co. at Deer Park, Houston, Texas.

# HIGHER EFFICIENCY, LUMMUS OIL HEATERS

## Lummus designs horizontal and vertical-tube oil heaters to any size, for any process—anywhere in the world

Major refiners confidently turn to Lummus on their important and difficult oil heater jobs.

In the last 25 years, the combined capacity of all Lummus oil heaters built has exceeded that of any other company in the world. The reasons: greater durability, more efficient operation, an absolute minimum of days lost to downtime.

Major refiners maintain large engineering and economics staffs who can evaluate the performance of important heating equipment. They buy more Lummus oil heaters because they *know* through statistical comparison that Lummus gives them *more heater per dollar.*

Lummus offers over a quarter of a century of oil heater experience for petroleum refineries, chemical and petrochemical plants. The highly trained engineering staff of the Oil Heater Division is ready in the Lummus New York office to give each job the full benefit of its accumulated know-how in this field.

Lummus oil heaters, of both special and standard design, range from 100,000 to 300,000,000 Btu per hour. As illustrated above, neither size, type nor location of the unit presents a problem to Lummus. Because Lummus offers *every* type of oil heater, you can be sure that we will recommend the *right*



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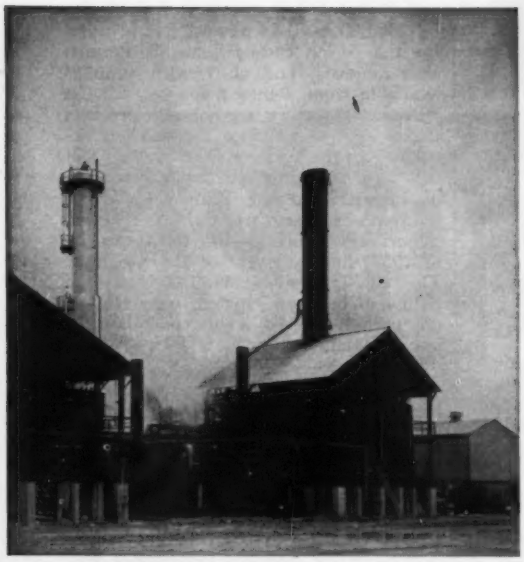
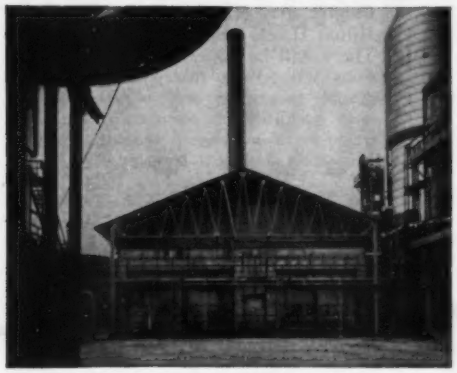
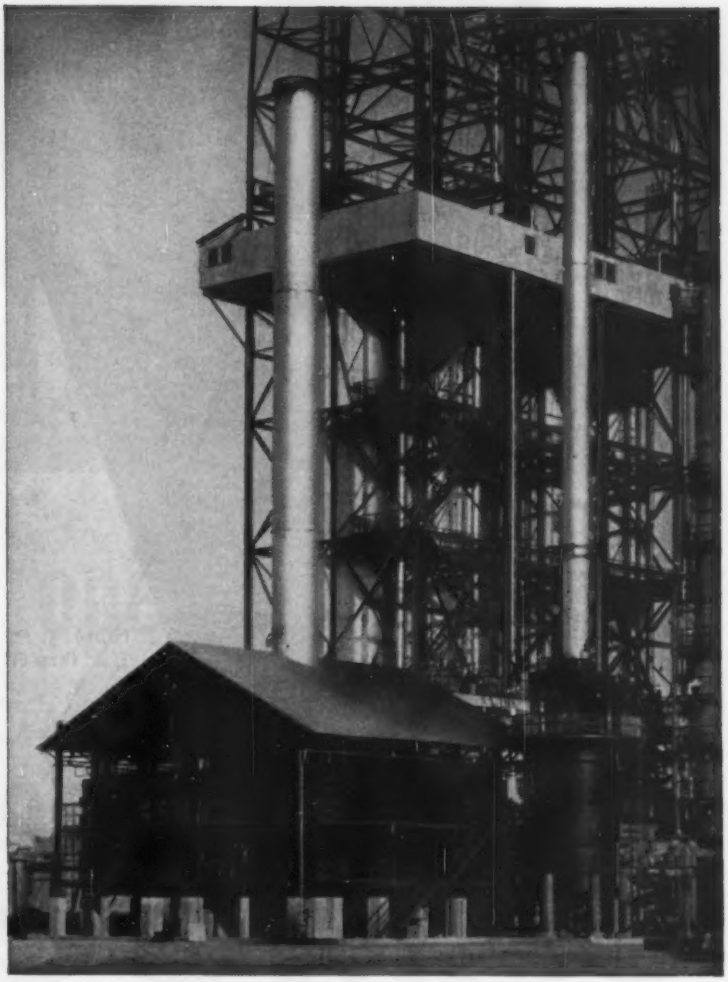




Crude heater for Socony Mobil at Paulsboro, N. J.



Delayed coker heater for the American Oil Co. at Yorktown, Virginia.

# MINIMUM DOWNTIME MAKE PREFERRED AMONG MAJOR REFINERS

unit for your needs. Complete Lummus facilities are available world-wide through any of the five international Lummus companies. Equipment is designed in New York, procurement is made through the nearest Lummus international office, and the cost of the job is payable in the currency of the country in which the procurement is handled!

Consult with Lummus on your next oil heater – large or small.

LUMMUS

THE LUMMUS COMPANY, OIL HEATER DIVISION
385 MADISON AVENUE, NEW YORK 17, N. Y.



For more data on advertised products, use Readers' Service Cards, last page.

LOW COST
light weight
**FORGED**
carbon steel

NOM. I. P. S.
1/2" thru 8"

# back-up flanges
# CAMCO

## FOR USE WITH SCHEDULE 5 and SCHEDULE 10 STAINLESS STEEL STUB ENDS and PIPE

Can be used with slip-on or lap joint stub ends where pressure and temperature problems are not encountered and Stainless is utilized to avoid contamination or corrosion.

Flange surfaces protected with a baked enamel finish.

CAMCO FITTINGS, INC.
301 STATE STREET
NORTH HAVEN, CONNECTICUT

For prices and dimensional data send for Schedule FCS-460

## *Happenings . . .*

be 250,000 bpd, as against 332,427 bpd for the period ending June 30. Permissible imports, together with supplies available from domestic sources, will be adequate to satisfy normal requirements for consumption during the quarter, according to the Interior Department. The new level is slightly less than the volume of imports that the Bureau of Mines estimates as the approximate actual import experience in the third quarter of 1957, the base year of the program. The cut in residual level was deeper than had been anticipated, even though the period covered is one of relatively low demand.

### Heat Transfer Conference To Be Held August 14-17

Some of the less esoteric aspects of heat transfer will be the subject of several panel discussions during the Fourth National Heat Transfer Conference and Exhibit of AICHE and ASME, Statler Hilton Hotel, Buffalo, N. Y., Aug. 14-17. There will be 30 exhibits. Panel discussions will cover discrepancies between design procedure and plant operation, heat exchanger standardization, heat transfer in advanced reactor concepts, and oxide fuel heat transfer.

### Conocoans to Get Time Off For Political Activities

A policy granting employes time off from work to participate in political activities has been initiated by Continental Oil Co. Those so participating will receive full pay. The plan covers all employes who have been elected and are serving as officers at the precinct level and above in the Democratic or Republican parties. It applies also to those desiring to serve as delegates to a regular political convention of either party. These individuals will be granted time off not exceeding three days. Party officers who must conduct election-day activities will also get time off.

### March LPG Production Up 10 Percent Over March 1959

Daily average production of natural gas liquids in March was 10 percent above March 1959, according to the Bureau of Mines. Daily average production of liquefied gases at refineries was 8.5 million gallons, 12 percent above a year ago. Demand for LPG for fuel and chemical uses in March was 32 million gallons, 10 percent above a year ago. Stocks of LPG including ethane totaled 579 million gallons, a decrease of 87 million gallons during March 1960. Underground stocks of LPG totaled 367 million gallons.


For more data on advertised products, use Readers' Service Cards, last page.

# New heat-resistant alloy

# SUPERTHERM
(Trade-mark)

# for castings operating in the 1800-2300°F range

## DEVELOPED AT OUR RESEARCH LABORATORIES

in Mahwah, N. J., Supertherm is field tested and proved. It is a superior alloy in this temperature range for static, centrifugal and shell-molded castings.

Mail the coupon, below, for technical information on composition*, physical and high-temperature properties.

*Patent Pending

---

Electro-Alloys Division
2026 Taylor Street
Elyria, Ohio

Please send me technical information on SUPERTHERM

Name_____

Title_____

Company_____

Address_____

City_____ Zone___ State_____

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

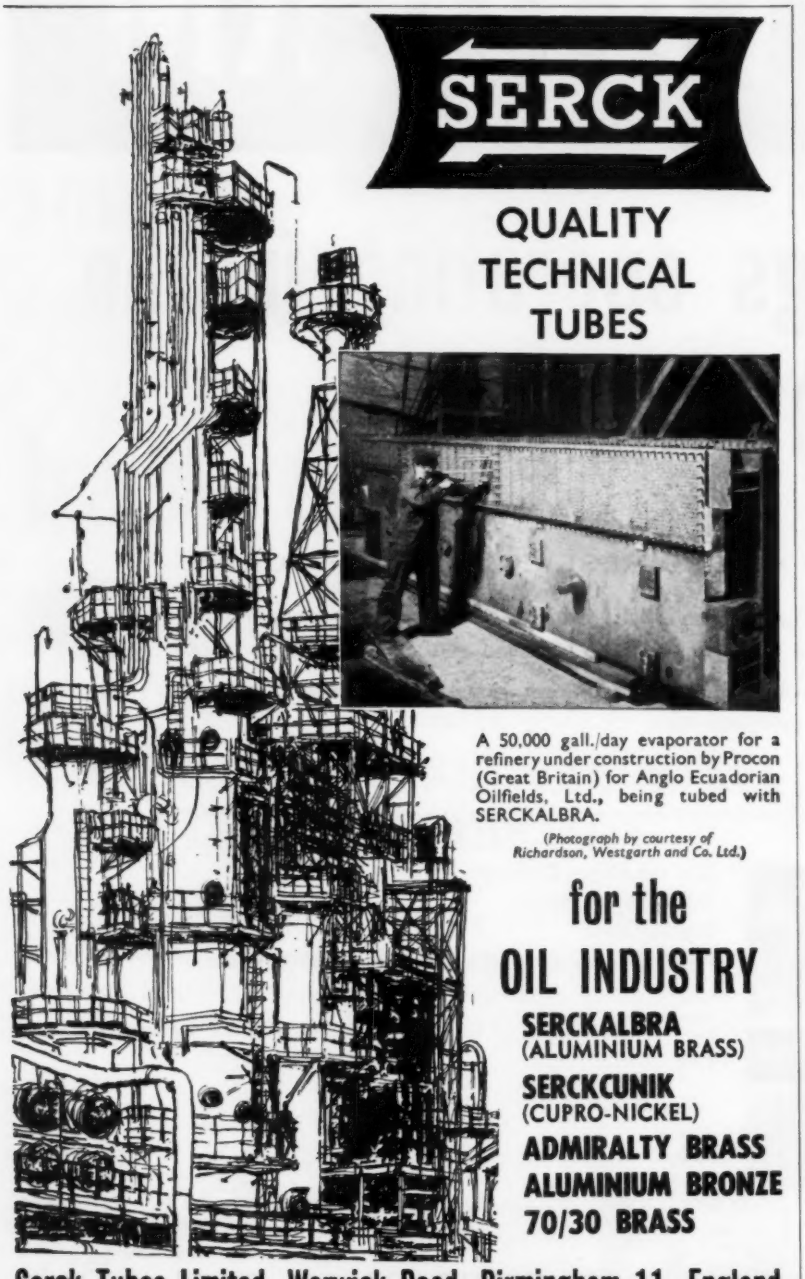


For more data on advertised products, use Readers' Service Cards, last page.

## *Happenings . . .*

### Pinkerton Cites Principle Hazards for Plant Guards

A list of the 15 principal plant safety hazards has been published by Pinkerton's National Detective Agency as a guide to the sort of thing that uniformed guards should be on the lookout for. Making his rounds of duty, the security guard should watch out for—correct if possible; at least report—these common hazards to safety: slippery floors; tripping hazards, such as hose lines, piping; inadequate warning signs at excavations, manholes; missing (or inoperative) entrance, exit lights; poorly lighted stairs; loose handrails or guard rails; aisle or street obstructions blocking access of fire equipment; overheated motors; loose or broken wiring; open fire doors; running motors not in use; defective ladders or scaffolding; leaks or unusual fumes; broken windows or doors; dangerously piled supplies or equipment.

SERCK

QUALITY TECHNICAL TUBES

A 50,000 gall./day evaporator for a refinery under construction by Procon (Great Britain) for Anglo Ecuadorian Oilfields, Ltd., being tubed with SERCKALBRA.

*(Photograph by courtesy of Richardson, Westgarth and Co. Ltd.)*

for the OIL INDUSTRY

SERCKALBRA (ALUMINIUM BRASS)

SERCKCUNIK (CUPRO-NICKEL)

ADMIRALTY BRASS

ALUMINIUM BRONZE

70/30 BRASS

Serck Tubes Limited, Warwick Road, Birmingham 11, England

*A member of the Serck Group.*


### Cuba Seizes Texaco, Shell And Esso Standard Plants

Russian technicians began operating U.S. and Anglo-Dutch owned refineries a scant 90 miles from the United States July 1. Cuba's Castro revolutionary government seized plants operated by Texaco Inc., Shell Oil Co., and Esso Standard Oil Co., because the firms refused to refine Soviet crude oil. The seizures made Cuba almost completely dependent upon Russian sources for crude oil. Some sources feel there is a possibility that Venezuela will eventually sell crude oil to Cuba. Value of the plants seized was placed at about $80 million.

### *- Changing Times -*

**New carbon disulfide process developed which employs liquid petroleum fractions instead of conventional methane gas.** Technical Director Carlisle M. Thacker, Taylor Fibre Co., Norristown, Pa., developed new process—said to **involve 25 percent less in plant investment—15 percent less production costs** than methane process.

**New Petrochemical operating division set up by Socony Mobil Oil Co.** to carry on broad-scale worldwide activity. **Named Mobil Chemical Co.,** new entity will form staff immediately—won't be limited as to types of products.

**Americans spend more for purchase and operation of their 70 million motor vehicles than combined national incomes of Canada and Mexico,** according to *Petroleum Today,* API publication.

**Negotiations to combine Clark Oil & Refining Co. and Intex Oil Co. are suspended.** In joint statement, companies said "several factors developed which make negotiations inappropriate at this time."

**American Oil Co. celebrates golden anniversary.** Established June 10, 1910—company started with three employes, a horse, and 270-gallon tank wagon for kerosene delivery.

**Texaco, Inc. will build $7.5-million research center at its Port Arthur, Texas, refinery** that will concentrate mainly on pilot research. More fundamental research activities will continue to be centered at Texaco's Beacon, N.Y., research center.

**President Eisenhower signs bill directing Public Health Service to study air pollution resulting from automobile exhaust** and make recommendations to Congress within two years.

**Lobitos Oilfields, London, is working out cash offer for Manchester Oil Refinery group of companies.** MOR has 3,000-bpd refinery and 40-percent interest in Belgian refining company, Albatros. Lobitos has 4,000-bpd refinery.

**New process for manufacture of phenol** is developed by Scientific Design



For more data on advertised products, use Readers' Service Cards, last page.

**ADDED SAFETY** is an important benefit when you equip your loading rack with the only gear-driven swivel joint on the market. No danger of the operator slipping on wet or icy decking while pulling down a loading arm. No chance of arm dropping or rising unexpectedly to spill hot or caustic products. No counterbalance arms, cables or pulleys to endanger clearance on the platform. The entire loading operation is constantly controlled by this easy-to-crank joint.

**TROUBLE-FREE SERVICE** offers an equally important advantage. This gear-driven swivel joint incorporates all the proven features of C-E's popular US-Type Joint. It breaks like a union for quick, easy repairs on location without special tools. No need to disturb bearings when repacking. Wide-spaced bearings and non-split races last longer and permit greater foot/pound loading. Separate races can be reversed easily to double their life.

C-E Gear-Driven Swivel Joints are available in 2, 2½, 3 and 4 inch sizes — styles 3, 4, 5 and 6 — in mild steel or with stainless steel wettable parts.

For more years of service, less maintenance expense and a safer loading rack, equip it entirely with Continental-Emsco's Gear-Driven Swivel Joints. There's a size and type to meet every requirement.

***Write, call or wire for the full catalog and price information.***

**CONTINENTAL-EMSCO COMPANY**
*A Division of The Youngstown Sheet and Tube Company*

*Industrial Products Division*
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DALPAC® 4

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Refinery customers have found that, in comparison with other inhibitors, Dalpac 4 (Hercules 2,6-di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of gasoline produced. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils where it prevents deterioration, and does not affect electrical properties.

*For additional information write:*

*Oxychemicals Division*
*Naval Stores Department*
***HERCULES POWDER COMPANY***
*900 Market Street*
*Wilmington 99, Delaware*

NO59-5R

## Changing Times (continued)

Co. Would make possible direct oxidation of benzene to phenol. SD says process **especially suitable for smaller package-plant installation.**

**House Rules Committee rejects proposal for creation of special Senate-House committee to study need for national fuels policy.** Committee took action behind closed doors after hearing more arguments for and against proposal.

**Rate of synthetic rubber use in United States continues to rise**—latest estimates pointing to **1960 consumption of 1.12 million long tons,** up 4.5 percent from 1959 record high, says B. F. Goodrich Co. Company looks for 1 to 2-percent decline in natural-rubber usage.

**First report of Russian crude oil offer to U.S. firm in recent years is made to Interamerican Refining Co.** Deal involves 31-gravity Black Sea crude at $1.90 a barrel, delivered at Bayonne, N.J. **Company refused offer**—said it would **never** use Russian crude.

Enterprising **Vincent H. Shea, of former Shea Chemical Corp.** (now part of Hooker Chemical Corp.) **moves into petrochemicals with formation of Chatham-Reading Corp., New York.** Firm, which projects annual sales of more than $50 million, will manufacture ethylene glycol, ethylene oxide, tetraethyl lead, antifreeze, and sulfuric acid.

**Three competitive engineering-constructor firms form joint company to win construction contracts abroad.** Firm, Chemical Works Projects, Ltd., was formed by Humphreys & Glasgow, Ltd., Simon Carves, Ltd., and P.G. Engineering, Ltd. Firm will aim for fertilizer and chemical-project contracts.

## Meetings Calendar

| | |
|---|---|
| **Aug.** | |
| 14–17 | **American Society of Mechanical Engineers-American Institute of Chemical Engineers,** Heat Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, N.Y. |
| **Sept.** | |
| 7– 9 | **ISA, ASME, AIEE, IRE, AIChE,** Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass. |
| 11–16 | **California Institute of Technology,** Management Development Conference, Campus, Pasadena, Calif. |
| 11–16 | **American Chemical Society,** National Meeting, New York. |
| 14–15 | **Western Petroleum Refiners Association,** Rocky Mountain Technical-Industrial Relations Meeting, Henning Hotel, Casper, Wyo. |
| 14–16 | **National Petroleum Association,** Annual Meeting, Hotel Traymore, Atlantic City. |
| –15 | **Natural Gasoline Association of America,** Rocky Mountain Regional Meeting, The Palliser Hotel, Calgary, Alba., Canada. |
| 15–16 | **ASME,** Engineering Management Conference, Hotel Morrison, Chicago. |
| 18–21 | **ASME,** Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans. |
| 21–23 | **ASME-AIEE,** Power Conference, Bellvue-Stratford Hotel, Philadelphia. |
| 25–28 | **American Institute of Chemical Engineers,** Meeting, Mayo Hotel, Tulsa. |
| 25–28 | **American Institute of Electrical Engineers,** Electrical Conference of the Petroleum Industry, Hotel Skirvin, Oklahoma City. |
| 26–30 | **American Welding Society,** National Fall Meeting, Hotel Penn-Sheraton, Pittsburgh. |
| 26–30 | **ISA,** Fall Automation-Instrument Conference and Exhibit, Annual Meeting, New York Coliseum, New York. |
| **Oct.** | |
| 6– 7 | **National Association of Corrosion Engineers,** Annual Western Region Conference, Sheraton-Palace Hotel, San Francisco. |
| 6– 8 | **NACE,** Southeast Region Conference, Dinkler-Plaza Hotel, Atlanta, Ga. |
| 9–12 | **ASME,** Rubber and Plastics Conference, Lawrence Hotel, Erie, Pa. |
| 10–11 | **ASME-AIEE,** Fuels Conference, Daniel Boone Hotel, Charleston, W. Va. |
| 11–14 | **NACE,** Northeast Region Conference, Prichard Hotel, Huntington, W. Va. |
| 13–14 | **California Natural Gasoline Association,** Fall Meeting, Hotel Miramar, Santa Monica, Calif. |
| 19–20 | **NACE,** Conference, North Central Region, Pfister Hotel, Milwaukee. |
| 25–28 | **NACE,** South Central Region Conference, Mayo Hotel, Tulsa. |
| 26–27 | **WPRA,** Question and Answer Session on Refining Technology. Rufus Garrett Hotel, El Dorado, Ark. |
| **Nov.** | |
| 14–16 | **American Petroleum Institute,** Annual Meeting, Conrad Hilton, Palmer House, and Congress Hotels, Chicago. |
| 27–Dec. 2 | **ASME,** Annual Meeting, Statler Hilton Hotel, New York. |
| **Dec.** | |
| 4– 7 | **AIChE** Meeting, Hotel Statler, Washington. |
| 7–11 | **NACE,** University of Illinois Corrosion Control Short Course, Urbana Campus. |
| 12–14 | **U.S. Public Health Service,** National Conference on Water Pollution, Sheraton Park Hotel, Washington, D.C. |



For more data on advertised products, use Readers' Service Cards, last page.

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Fisher-Continental Type 480 will give you all 3 on your next

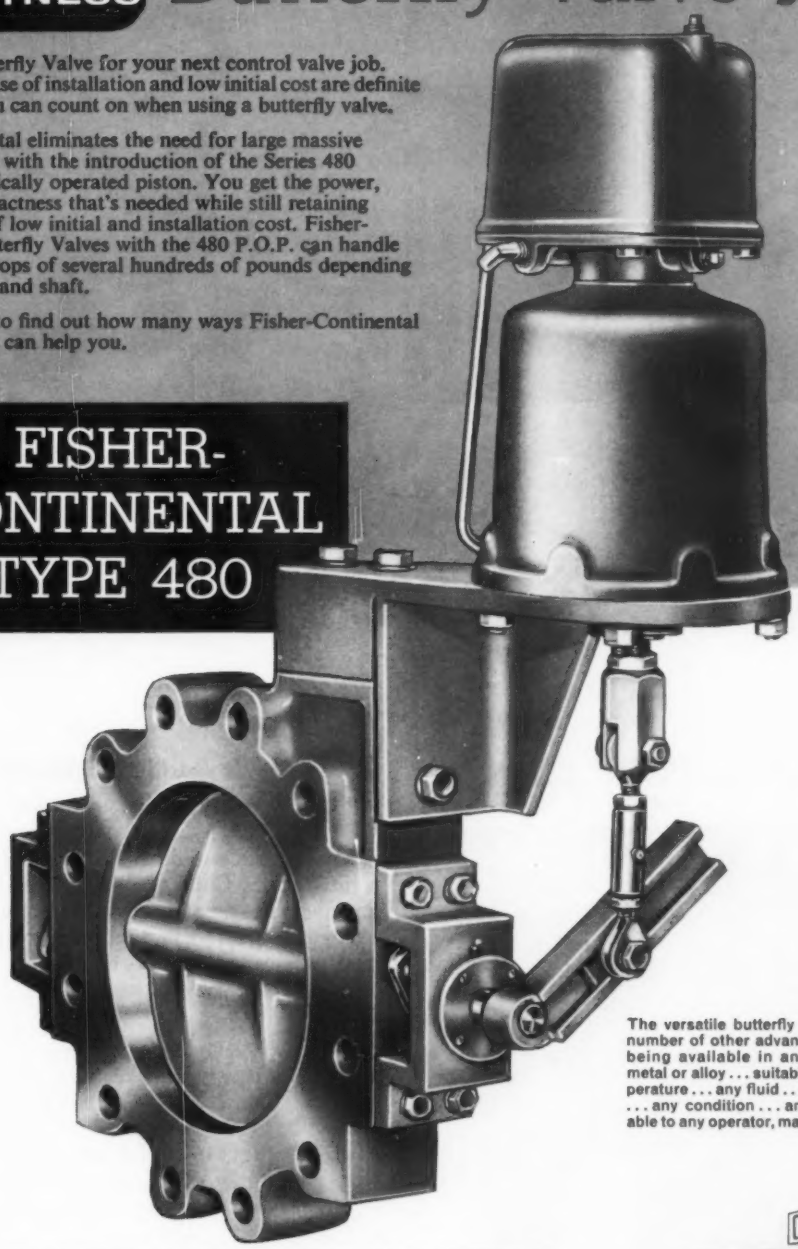
# Butterfly Valve Job

Consider a Butterfly Valve for your next control valve job. Compactness, ease of installation and low initial cost are definite plus features you can count on when using a butterfly valve.

Fisher-Continental eliminates the need for large massive power actuators with the introduction of the Series 480 P.O.P. pneumatically operated piston. You get the power, speed and compactness that's needed while still retaining the advantage of low initial and installation cost. Fisher-Continental Butterfly Valves with the 480 P.O.P. can handle high pressure drops of several hundreds of pounds depending on size of body and shaft.

It will pay you to find out how many ways Fisher-Continental Butterfly Valves can help you.

FISHER-CONTINENTAL TYPE 480



The versatile butterfly valve offers a number of other advantages such as being available in any size... any metal or alloy... suitable for any temperature... any fluid... any pressure ... any condition... and it is adaptable to any operator, manual or power.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

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CONTINENTAL

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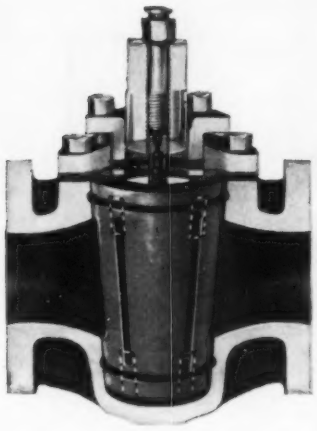
SINCE 1880

# the idea:

***Simplicity Is Basic To Efficiency and Economy***

One of the world's first valves, plug cocks invented by the Chinese centuries ago, had only one moving part—the plug. Even the earliest craftsman recognized the fact that simplicity of design almost always means a device that works better, lasts longer and costs less to use.

# the application:



*How It Helps Give You A Better Valve*

In the modern Rockwell-Nordstrom lubricated plug valve there are only three rugged, basic parts . . . plug, body and cover. The plug is the only moving part. Compared to other valves, nothing could be simpler or more efficient. Yet the many advantages of simplicity are actually multiplied by *lubrication* in these valves. Pressurized lubrication jacks the plug, keeping it free for instant ¼-turn operation. It also forms an instantly replaceable, impenetrable seal against leakage, and prevents metal-to-metal wear.

# the benefits:

***Longer Valve Life At Lower Cost . . . Leak-proof Sealing . . . Reduced Down Time . . . Completely Protected Seating***

The 6 million Rockwell-Nordstrom lubricated plug valves now used in a wide variety of industries are translating these benefits into dollars and cents savings day after day. Rockwell-Nordstrom is the most complete line of lubricated plug valves (sizes from ½" to 36"; pressures to 15,000 lb), lubricants and operating accessories. For *practical* help in solving your flow control problems, see your supplier or write: Rockwell Manufacturing Company, Dept. 95-G, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited. If you live outside the U. S. or Canada, write: Rockwell International, S.A., Geneva, Switzerland.

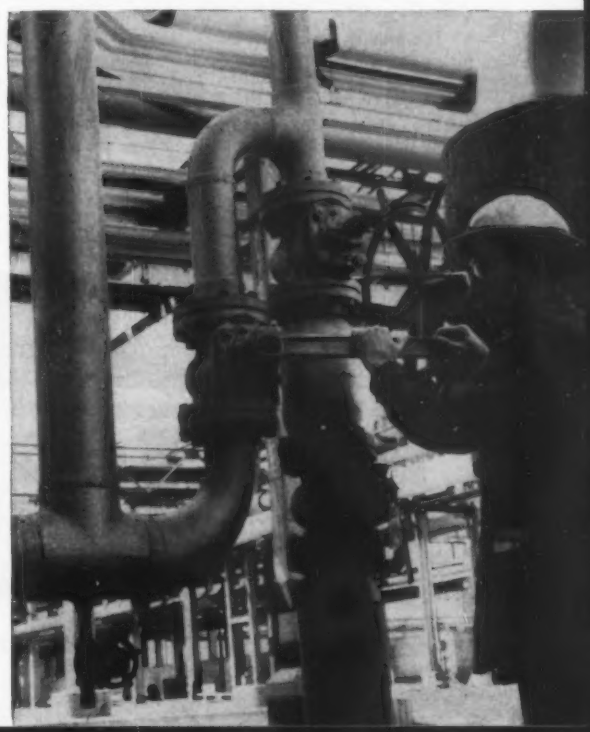
***Lubrication Makes The Difference***

ROCKWELL-Nordstrom VALVES

another fine product by

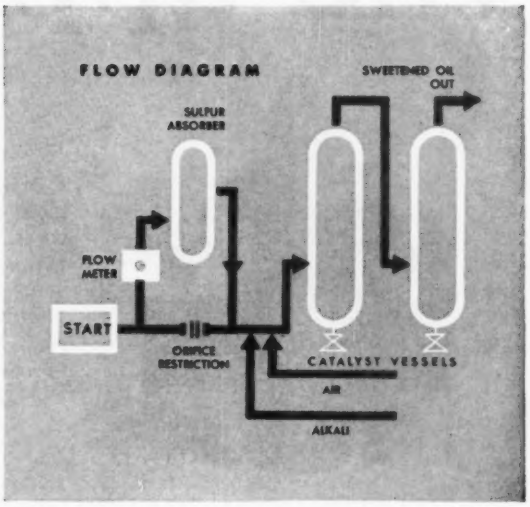
**ROCKWELL**

For every refining valve need (Toluene plant service below) there is a Rockwell-Nordstrom valve to insure positive, leak-proof control.



PRODUCT IMPROVEMENT WITH

# PETRECO




## IF SWEETENING IS ONE OF YOUR REFINERY PROBLEMS...

### these facts about Catalytic Sweetening† may show you the answer:

**LOW OPERATING COSTS:** The average treating costs of Petreco Bender treating units are about 0.5 cents per barrel. Copper chloride or doctor treating costs, exclusive of amortization, generally exceed 1.0 cents per barrel. *The value of the volume loss in doctor treating alone often exceeds the total operation and amortization costs of Petreco Bender catalytic sweetening.*

**SWEET NON-CORROSIVE PRODUCT:** As compared to doctor treating, less sulfur is used, resulting in the delivery of a consistently non-corrosive product. *The use of less sulfur also lessens octane loss.*

**ELIMINATES AIR AND WATER POLLUTION:** Processing is in a closed system, eliminating air pollution and the attendant safety hazards. This eliminates open batch type agitators, thereby assisting in safety programs. *There is no "black strap" carry-over or carry-under to contaminate waste disposal systems.*

The product from the Petreco Bender unit is low in trace metal ions. Where a water wash is required to meet local product specifications, emulsion problems are not encountered due to the cleanliness of the Bender treated oil.

The only spent alkali withdrawn from the Bender unit each day is the small amount not consumed in the process.

**HIGH YIELD:** There is no volume loss in the system other than sampling and spillage. The volume loss in other sweetening processes is the greatest expense factor.

**CONTINUOUS REGENERATION NOT NECESSARY:** The catalyst retains its activity for long periods of time. This is made possible by the continuous addition of small quantities of air and alkali. Catalyst life without reactivation is usually two years or more. *Two Petreco Bender plants have been operating for over three years without any reactivation of the original catalyst.*

**LOW INSTALLATION COST:** *Unit cost for new equipment is comparatively low, ranging from $15 to $30 per barrel of daily throughput capacity.* If existing vessels are available and appropriate for conversion, this cost can be substantially reduced. Very often the charge may be taken directly from a distillation unit with existing pumps, exchangers and instrumentation, reducing the installation cost further.

**SMALL TREATING AREA REQUIRED:** Where ground areas are congested, the area occupied by any treating unit is of great importance. The plot dimensions for a 5,000 bpd Petreco Bender unit, for example, would be approximately 20′ x 35′.

*°PETRECO is a registered trademark of Petrolite Corporation.*

*† For middle range distillate streams such as kerosine, stove oil, light gas oil, No. 2 fuel oil, coker naphtha and catalytic gasoline.*

B-60-2

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3202 South Wayside Drive (P.O. Box 2546), Houston 1, Texas
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# Men in The Industry...

**L. F. McCollum (second from left), president of Continental Oil Company, receives honorary LL.D. degree from Dr. R. C. Goodwin, acting president of Texas Technological college. Dr. Ben G. Hennecke (third from left), president of the University of Tulsa, presents an honorary D.S. degree to Harold G. Osborne, senior vice president of Continental Oil Co.**

## Three Continental Executives Are Awarded Honorary Degrees

Three Continental Oil Co. executives —L. F. McCollum, president, Harold G. Osborn, senior vice president, and Wayne E. Glenn, general manager of production —have been presented honorary doctor's degrees from American universities. McCollum was presented an honorary LL.D. degree from Texas Technological College at the school's commencement exercises on May 30. Awarded the degree "in recognition of distinguished service to business and industry," he also delivered the commencement address at Texas Tech. Osborn received an honorary D.S. degree from the University of Tulsa for "distinguished service to education" at that school's commencement exercises on May 29. Glenn was presented an honorary Doctor of Engineering degree from the Montana School of Mines, and also delivered the commencement address at exercises on June 6.

Haring

Kilgore

**J. M. Haring** has been named president of Southwest Engineers, Inc., a newly formed subsidiary of Southwest Industries, Inc. The new firm will specialize in engineering and design of all types of facilities for the processing of oil and gas. Other new officers include **C. B. Kilgore** and **Emil G. Nasser,** vice presidents. Haring had been with Southwest Industries four years prior to his new appointment. Nasser was previously a process engineer for The Fluor Corp., and also worked for Shell Oil Co. Kilgore, with Fluor eight years, was a design supervisor and layout designer.

Nasser

**William J. Selfridge** has been appointed employe relations manager for Mobil Oil Co.'s local manufacturing facilities, including the Torrance, Calif., refinery and the Vernon manufacturing plant. Selfridge was formerly employe relations head at Mobil's East St. Louis refinery.

**Clarence B. Round,** Ponca City, Okla., has been promoted to manager of manufacturing for Continental Oil Co.'s Rocky Mountain Region, with headquarters in Denver. Formerly assistant superintendent of Conoco's Ponca City refinery, he succeeds **W. F. Brown,** who has joined the company's executive offices at Houston as special assistant to the senior vice president. Round joined Conoco at Ponca City in 1929 and transferred to the

Round


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***FMC offers Dependability, Manufacturing skill, Choice of products for Gasoline Additives***

**Dependability** – FMC protects the refiner by producing ignition control additives from basic raw materials...assuring you of optimum quality control throughout the production process, and providing you with a dependable source of supply for these products.

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If you need a phosphorus additive to eliminate engine knock, reduce surface ignition and spark plug fouling, you can rely on the experience and facilities of FMC. Write for more information about FMC gasoline additives. We will be glad to show how these products can meet your most exacting specifications.

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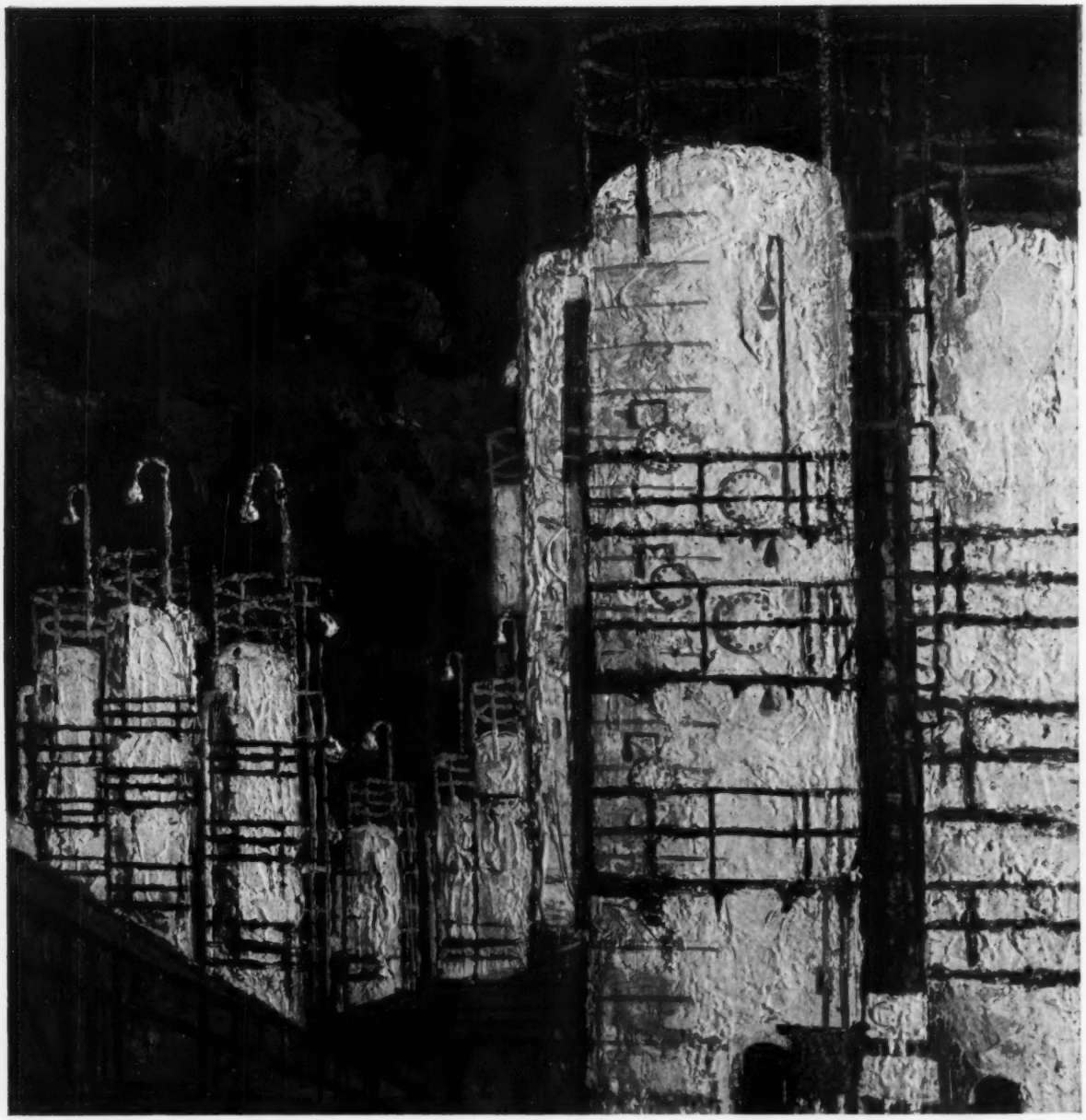

**More drying per dollar in nine towers showed Columbia Gulf Transmission why it pays to**

# *mix imagination with Alcoa Aluminas*

Nearly ½-million lbs of Alcoa® Activated Alumina is giving Columbia Gulf Transmission Co. maximum drying capacity per dollar in one of the world's largest natural gas drying operations. Used in nine towers at the company's Rayne, Louisiana, compressor station, the activated alumina dries 690 MMSCF of natural gas per day. Average water content of gas entering the towers is 5-6 lbs water/MMSCF. Water content of the effluent gas is below ½ lb water/MMSCF. Each tower is on stream for 24 hours with a reactivation time of 6 hours. Columbia Gulf Transmission has found that no other desiccant can furnish such efficient drying at such low cost.

When effective, economical drying is your aim, it pays to mix imagination with Alcoa Activated Aluminas—the oldest commercial desiccant available and still the most efficient. For detailed data, send for a free copy of the Alcoa White Data Sheets and a comprehensive Gas and Liquid Dehydration Questionnaire. Aluminum Company of America, Chemicals Division, 708-G Alcoa Building, Pittsburgh 19, Pa.

**ALCOA CHEMICALS**
ALUMINUM COMPANY OF AMERICA

**For finer products . . . let Alcoa add new dimension to your creative thinking!**

## *Men . . .*

Headquarters Manufacturing Department in 1940. He was assistant to the vice president in charge of manufacturing before becoming assistant superintendent of the Ponca City refinery in 1954.

**John M. Brown,** who has been refinery manager for Lake Superior Refining Co. since February 1959, has been elected to replace **Edwin F. Nelson** on the board of directors for Lake Superior. Nelson is retiring as president and director of Lake Superior.

**Roy A. Clifford,** Houston, has been promoted to assistant director of employe communications for Continental Oil Co. He was assistant manager of personnel relations for the company's Petrochemical Department.

**Thomas M. Welch** has been chosen to head the Plans Division of Humble Oil & Refining Co. He was manager of the Plan Development and Social Security Division of Esso Standard Oil Co., which merged into the new Humble firm last Jan. 1.

**Sri A. Subramani** has been named works manager of the Assam Oil Co. refinery at Digboi, Upper Assam, India. Subramani, who is replacing **J. H. Purdie,** is the first Indian to become works manager of the company.

**Theodore E. Casselman, Jr., and Wilbur S. Roberts, Jr.,** have been elected vice presidents of Stone & Webster Engineering Corp., New York. Casselman was manager of the firm's New York office and Roberts was manager of the company's new business activities.

**Howard S. Bunn,** president of Union Carbide Corp., was given the honorary degree of doctor of engineering during the 92nd commencement exercises held at Lehigh University, Bethlehem, Pa.

**Dr. Herman A. Bruson** has been named vice president for research of the Chemicals Division, Olin Mathieson Chemical Corp. Dr. Bruson was formerly director of research in organic chemicals for the firm.

**John H. McCulley** has been promoted to general foreman of the Cracking and Polymerization Department at Humble Oil & Refining Co.'s Baytown refinery. He has served in the refinery's Technical Service Division, laboratory, and process control.

**Herman A. Engel, Jr.,** has been named coordinator of economics and evaluation for Union Texas Natural Gas Corp. Formerly manager of the company's Canadian Division, Calgary, he assumed new duties in Houston on June 15, 1960. **Kenneth W. Germond,** presently


*SWECO process equipment...*

# Three Ways More Dependable

**Seasoned Engineering Staff**
SWECO engineers are constantly meeting petroleum industry challenges of new extremes in temperature and pressure. They develop improved equipment designs and methods to obtain the highest thermal and mechanical efficiency for economical, long-range operation.

**Specialized Production Facilities**
Construction of heat exchangers, pressure vessels, steam jet ejectors and other process equipment requires special production skills, equipment and experience. SWECO's 40 years of fabrication experience, much of it with special metals and alloys, results in high quality standards and reasonable production costs. Continuous quality control is maintained throughout production with all SWECO equipment thoroughly tested before shipment.

**"One-Man" Project Responsibility**
A *single* SWECO Sales Engineer serves as your project co-ordinator and expediter. He communicates your equipment requirements to engineering and works closely with production to assure that your specifications and delivery dates will be met. Because he *knows* your unit, he gives you straight answers and immediate service.

**Southwestern Engineering Company**

SWECO

4800 Santa Fe Ave., Los Angeles 58
*Engineers—Constructors—Manufacturers*

For illustrated literature on SWECO heat exchangers, pressure vessels, steam jet ejectors and other process equipment, write for your copy of Bulletin 14-333.




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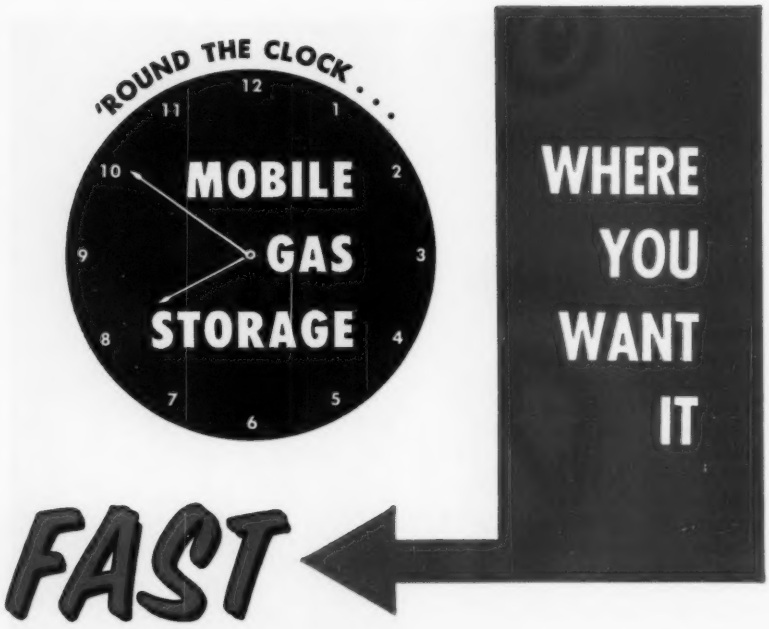

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Around the clock around the nation — Taylor-Wharton Gas Transports put mobility in your gas stores moving your gas to where you need it, when you need it.

Utilizing a special trailer with either single or tandem axle chassis, upon which are mounted various numbers of pressure vessels (depending upon the gas capacity desired). Large quantities of gas can easily be moved about or put into semi permanent storage.

More than a Century in Harrisburg 2, Pa.

H HARRISBURG STEEL CO.

Division of HARSCO CORPORATION

CYLINDERS TUBES FLANGES COUPLINGS


## Men . . .

exploration manager of the Canadian Division, will succeed Engel as manager in Calgary.

**P. W. Judah** has been named manager of two major divisions within Mobil Chemical Co., the newly formed chemical enterprise of Socony Mobil Oil Co., Inc. Judah, who has served as manager of Socony Mobil's Petroleum Chemicals Department since November 1956, will head the Basic Petroleum Chemicals Division and the Paint and Special Products Division. He will be in charge of both during the organizational period of Mobil Chemical.

**Edmund Field,** senior research associate at Standard Oil Co. (Indiana), has been named chairman of the Catalysis Club, Chicago. **Herman E. Ries, Jr.,** research associate for Standard, has been elected a member of the club's Executive Committee. The club is made up of scientists in the Chicago area who are leaders in the field of catalysis.

**Ralph Andres Brown and Boris Franzus** have joined the staff of Esso Research and Engineering Co. Brown was with The Atlantic Refining Co. for 19 years. Dr. Franzus came to Esso Research from Phillips Petroleum Co., where he worked for six years.

**Dr. J. T. Horeczy** has been promoted to research associate in Humble Oil & Refining Co.'s Research and Development Division, Baytown. He will continue to direct activities of the Research Section engaged in exploratory research on chemicals.

**J. W. Braun** has been appointed superintendent of the Refining Section at The Atlantic Refining Co.'s Philadelphia refinery. Braun has been superintendent of the Chemicals Section since 1956. He is replacing **Dr. H. V. Hume,** who is retiring after 33 years of service.

**E. W. Biggers** has been promoted to assistant foreman of the Distillation Department at Humble Oil & Refining Co.'s Baytown refinery. He was a member of the Distillation Section, Technical Division.

**Joe H. Miller** has been named manager of process and control engineering for Suntide Refining Co., Corpus Christi, Texas. Miller was chief process engineer for DX Sunray Oil Co.'s Tulsa refinery.

**Dr. F. H. Field** has been promoted to research specialist in Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas.

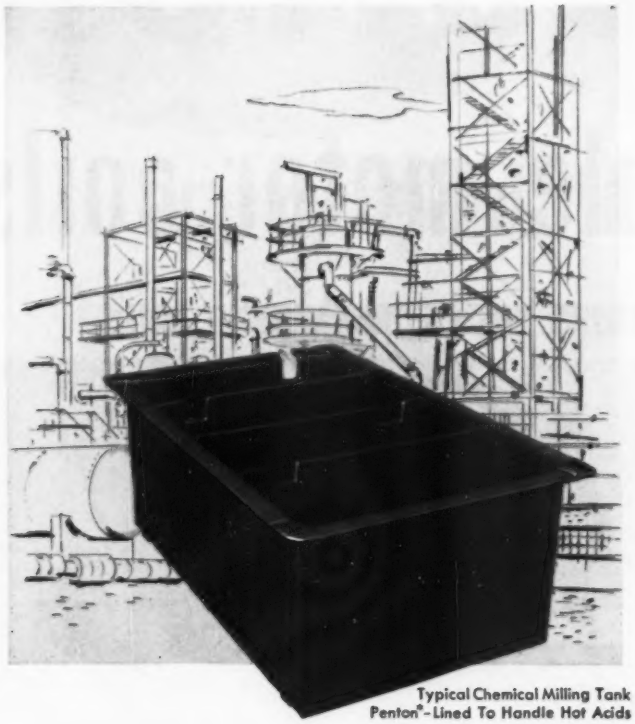
**Ernest Moncrief** has been named vice president and coordinator of foreign operations and affiliates, The Fluor Corp. **James P. Wiseman** becomes vice president, Fluor's Mid-Continent Division,



For more data on advertised products, use Readers' Service Cards, last page.

# GAR-LINE PENTON TANK LININGS

## for Corrosion Resistant Service



Typical Chemical Milling Tank Penton®-Lined To Handle Hot Acids

**New GAR-LINE Penton Tank Linings offer economical, high-temperature protection against corrosion.** Where only more expensive materials were previously used, GAR-LINE Penton Tank Linings are proving their ability to perform as well as—and better—in many corrosive exposures involving elevated temperatures.

**Unique Properties.** GAR-LINE Penton Tank Linings possess characteristics that provide a highly practical means of upgrading low-cost metal substrates. Penton is applied using conventional techniques and equipment. *Mechanically*, the linings exhibit excellent tensile strength at high temperatures, good dimensional stability and low water absorption . . . *Chemically*, they resist all inorganic acids except fuming nitric and fuming sulfuric.

**Widely used in chemical processing.** Tanks for plating solutions, chemical milling operations, and the storage and handling of other corrosive fluids are typical of the many uses of GAR-LINE Penton Tank Linings.

**Applied by carefully selected** and authorized applicators. The experience of these tank lining experts guarantees satisfactory GAR-LINE Penton installation, prevent expensive failure due to improper application. Approved applicators include:

AUTOMOTIVE RUBBER CO., INC.
12580 Beech Road
Detroit 39, Michigan

BUCKLEY IRON WORKS
21 Christopher Street
Dorchester, Massachusetts

THE FORTUNE COMPANY
1906 North Mosley
Wichita 14, Kansas

GOODALL RUBBER CO.
2050 N. Hawthorne Avenue
Melrose Park, Illinois

HANSZEN PLASTICS CO.
835 S. Good-Latimer Expressway
Dallas, Texas

INNER-TANK LINING CORP.
4777 Eastern Avenue
Cincinnati 26, Ohio

ELECTRO CHEMICAL ENGRG. & MFG. CO.
750 Broad Street
Emmaus, Pennsylvania

MERCER RUBBER CORP.
Highway 46, Cor. Huyler
Little Ferry, New Jersey

METALWELD, INC.
Scotts Lane & Abbottsford Rd.
Philadelphia 29, Pennsylvania

RUBBER MILLERS, INC.
707 S. Caton Avenue
Baltimore, Maryland

ST. LOUIS METALLIZING CO.
625 S. Sarah Street
St. Louis 10, Missouri

# GARLOCK

**Investigate GAR-LINE Penton** Tank Linings as the answer to your corrosion problems. For more information, contact the applicator nearest to you. Or, write for data on Penton; information also available on Teflon Anti-Stick and Teflon† Tank Linings. Special Products Dept., Garlock Inc., P.O. Box 612, Camden 1, New Jersey.

*Registered Trademark, Hercules Powder Company
†Registered Trademark, The DuPont Company

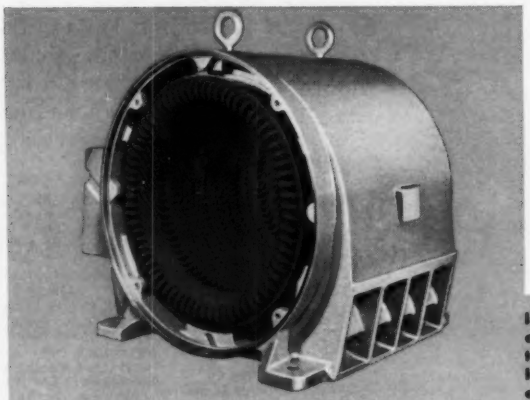


For more data on advertised products, use Readers' Service Cards, last page.

# UNEXCELLED PROTECTION

## for vulnerable motor coils

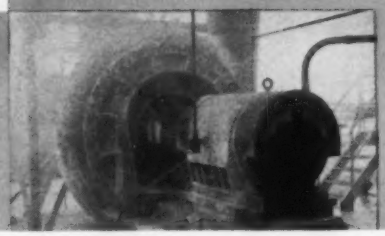
### FOR INTEGRAL H. P. MOTORS WITH FORM-WOUND COILS



**WOUND STATOR**—Core and frame are dipped in EPA-SEAL epoxy resin and baked before winding. Slot cells are epoxy-glass, and all connections are taped with epoxy-mica and glass tape. After winding, the entire stator is given the EPA-SEAL vacuum-pressure process described below.

**IMPREGNATED COIL**—Finished coil is entirely covered with glass tape before impregnation. Where leads leave the coil, special epoxy compound seals against entrance of moisture. The entire slot section is protected by epoxy-mica wrapper.

**NOW OPERATING.** One of the first epoxy-insulated, form-wound motors in service was the 350 hp Epa-Seal motor shown below. It operates under severe corrosive atmospheric conditions, plus constant spray from nearby cooling tower.



The Elliott EPA-SEAL epoxy insulation system for integral hp motors includes the application of epoxy resins to all vulnerable parts, and a unique process of vacuum preconditioning and pressure impregnation. Vacuum preconditioning is accomplished by placing wound stators in a tank which is sealed and evacuated. This removes all air and moisture from within the coils and coil slots.

Then while still under vacuum, impregnation is accomplished by pumping special epoxy resin into the sealed tank under pressure. The combined vacuum and pressure treatment assures deep penetration of the resin into the innermost spaces of the coils and coil slots. The result is a tough, impervious, resilient, void-free protection against salt water, acids, alkalis, solvents, cutting oils, carbon-black, abrasives. This exclusive Elliott C-W insulation withstands heat, cold, vibration, resists chipping and cracking, takes cold shock and thermal cycling unharmed. EPA-SEAL epoxy-insulated motor stators with form-wound coils have been completely submerged in water for three months without impairment of insulation resistance or dielectric strength.

WO-1

# Elliott's tough, resilient

# EPA-SEAL

# epoxy insulation system

## FOR INTEGRAL H. P. MOTORS WITH RANDOM-WOUND COILS

**ENCAPSULATED STATOR—Entire wound stator is encapsulated in EPA-SEAL epoxy resin by vacuum-pressure impregnation. Epoxy resin fills slots completely, penetrates coils. Protects laminations, too.**

**Note in sectioned stator core below how EPA-SEAL completely fills the slots. All conductors are completely encased by this unique epoxy insulation system.**

**NO VOIDS—Vacuum preconditioning and pressure impregnation assure void-free insulation. Phase insulation is entrapped in the epoxy resin, which even penetrates into lead sleeving. Note how EPA-SEAL bonds to the stator core, seals against moisture. Relatively thin build-up over coils permits rapid dissipation of heat from conductors.**

For motors with random-wound coils, the method customarily used for encapsulating consists of applying an external coating over exposed coil ends. But with the Elliott EPA-SEAL system, the entire wound stator is encapsulated in EPA-SEAL epoxy resin by vacuum-pressure impregnation. In addition, stator and rotor laminations are treated with a special anti-corrosive epoxy coating. All hardware is protected by a corrosion-resistant treatment. Weatherproof conduit boxes are standard. Motors are adaptable to NEMA Type I weather protection. Epa-Seal random-wound motors have run while completely submerged in water for more than 1000 hours, without failure.

Elliott Epa-Seal motors are ideally suited for service in chemical and petrochemical plants, paper mills, rubber mills, in deep mines or coastal service—wherever moisture or corrosive atmospheres demand superior motor insulation.

***WRITE FOR*** **New Bulletin PB 6000-12, giving further details on the remarkable EPA-SEAL insulation system. Crocker-Wheeler Plant, Elliott Company, Jeannette, Pa.**

**ELLIOTT Company**

**CROCKER-WHEELER PLANT • JEANNETTE, PA.**



For more data on advertised products, use Readers' Service Cards, last page.

## Men . . .

Houston, Moncrief's former position. In his new role, Moncrief will coordinate the activities of parent company subsidiaries and affiliates, including: The Fluor Corp. of Canada, Ltd.; Fluor Engineering & Construction Co., Ltd. of London; Fluor-Schuytvlot, N.V. of Haarlem, Holland; Singmaster & Breyer, Inc.; and H. G. Acres and Co., Ltd. Moncrief will operate from Fluor's headquarters in Los Angeles.

**Don F. Ferguson** has been named vice president in charge of the Petroleum Refinery Division of Hydrocarbon Construction Co., Houston.

**H. H. Meier** has been named manager of the Humble Division Manufacturing Department of Humble Oil & Refining Co. Meier, who has been serving as assistant plant manager of the Baytown refinery, will succeed **Dr. Charles F. Jones.** Jones is joining Humble's headquarters as manager of the Economics and Planning Department.

**L. A. Bullington and B. S. Greenwood** have been promoted to senior supervising engineers in the Technical Division at Humble Oil & Refining Co.'s Baytown refinery. Bullington heads the Economic Analysis Section and Greenwood the Butyl and Butadiene Section.

**William F. Kenney,** vice president and general counsel of Shell Oil Co., has been elected chairman of the Committee on Public Affairs, API. He succeeds **Kerryn King,** vice president of Texaco Inc.

**Leonard P. St. Clair,** 89, pioneer California oil man and a former president of Union Oil Co., died June 21 after a long illness. He had been president of the Independent Oil Producers' Agency, a member of the board of directors of Union Oil, and had served on the Pacific Coast War Service Committee during World War I.

## Industry Quiz

(answers to quiz on page 18)

1. True. "New Charts Speed Drum Sizing" on Page 168 shows a fast way to size both dry and reflux drums.

2. (a) 25 to 40 cents per pound. To this cost must be added the approximate material cost to find selling price. For more useful data in chart form, see "How to Estimate Fractionating Column Costs" on Page 119.

3. False. Mount vertically only. There are a host of other design tips in the article "Piping of Pressure Relieving Devices" on Page 127.

4. (a) 10 times. "Use Computers to Select Exchangers" on Page 149 tells what it costs and how to program it.

5. (c) Increase in throughput of 23 percent. For changes in other variables see "Add Oxygen for Better Cat Operation," Page 161.

6. True. For other items which identify all plant expenditures to product, see "How to Control Total Costs" on Page 112.

7. False. Photo-drafting is faster and it is usually less expensive than a conventional drawing. For other advantages of photo-drafting and how to set up a system in your plant, turn to Page 164.

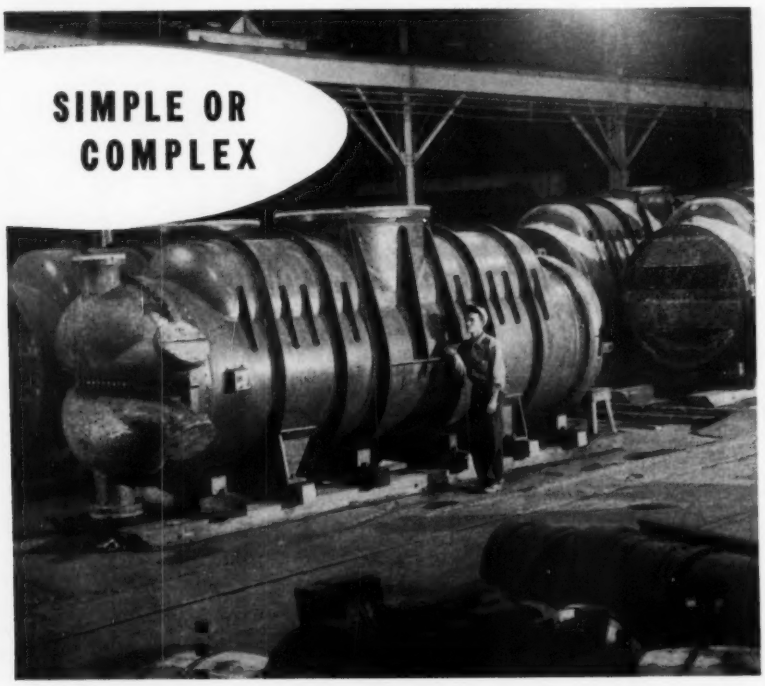
8. Second (to the United States). Author Ross also says that Russian engineers are more specialized than their U.S. counterparts in "How to Check the Russian Literature," Page 143.

9. False. In his article on "Unusual Foundation Design For Tall Towers," Page 103, E. V. French says that such impulses would be damped. He also says that damping would be effective to some degree whether one or both towers were in motion or regardless of wind direction.

10. (b) 0.1 cent per pound increase in the price paid for acid can mean operating at a loss. "How Raw Materials Affect Costs," Page 108.

11. None. Perform *all* tests in critical failure say Messrs. Freedman, Dravnieks, and Ostrofsky. See how to go about other investigations in this "Corrosion Measure Short Course," Page 145.

12. (b) 20,000 barrels. Greater capacity makes low temperature storage even more economical, as you'll find in "How to Determine Low Temperature Storage Costs" on Page 115.


EFCO's Four Point Program Provides:

- service-proved engineering design
- guaranteed job-ratings
- complete fabricating facilities
- technical service before, during and after installation

No job is too complicated for Efco's heat-transfer specialists. One reason that Efco does it *right* is its many years of experience in designing and fabricating heat-exchangers for the wide range of temperatures and pressures represented by ethylene plants and platinum catalyst reforming units. We are recognized specialists in handling all grades of carbon, alloy, and stainless steels, nickel, aluminum, and special low-temperature materials.

EFCO

ASK OUR GULF COAST CUSTOMERS—THEY KNOW US WELL

Write for General Catalog

ENGINEERS AND FABRICATORS, INC.

P. O. BOX 7395 • HOUSTON 8, TEXAS

119

# Pennsalt service helps you cash in on HYDROFLUORIC ACID alkylation

The striking savings you can get when you alkylate with hydrofluoric acid are a matter of record. And Pennsalt's long, specialized experience with AHF can help you take advantage of these savings. We'll show you how to handle, store and use Pennsalt AHF safely and confidently . . . advise you on valves, pumps, piping and materials of construction . . . help you with employee training programs . . . give you personalized technical assistance tailored to your needs. Ask your Pennsalt representative, or write for full information. Industrial Chemicals Division, PENNSALT CHEMICALS CORPORATION, Three Penn Center, Philadelphia 2, Pa.

- Lower catalyst cost
- Shorter reaction time
- Faster catalyst settling
- Reduced acid inventory
- Lower cooling expense
- Minimum spent acid problems
- Minimum side reaction products

**New HF Handling and Data Book.** Includes text, drawings, graphs, tables, photos. Write on your letterhead for Bulletin S-148.

***See our complete listing in Chemical Materials Catalog***

**Industrial Chemicals Division**

SALES OFFICES: CHICAGO • DETROIT • NEW YORK • PHILADELPHIA PITTSBURGH • ST. LOUIS • APPLETON • ATLANTA TACOMA • PORTLAND

INDUSTRIAL QUÍMICA PENNSALT, MEXICO CITY

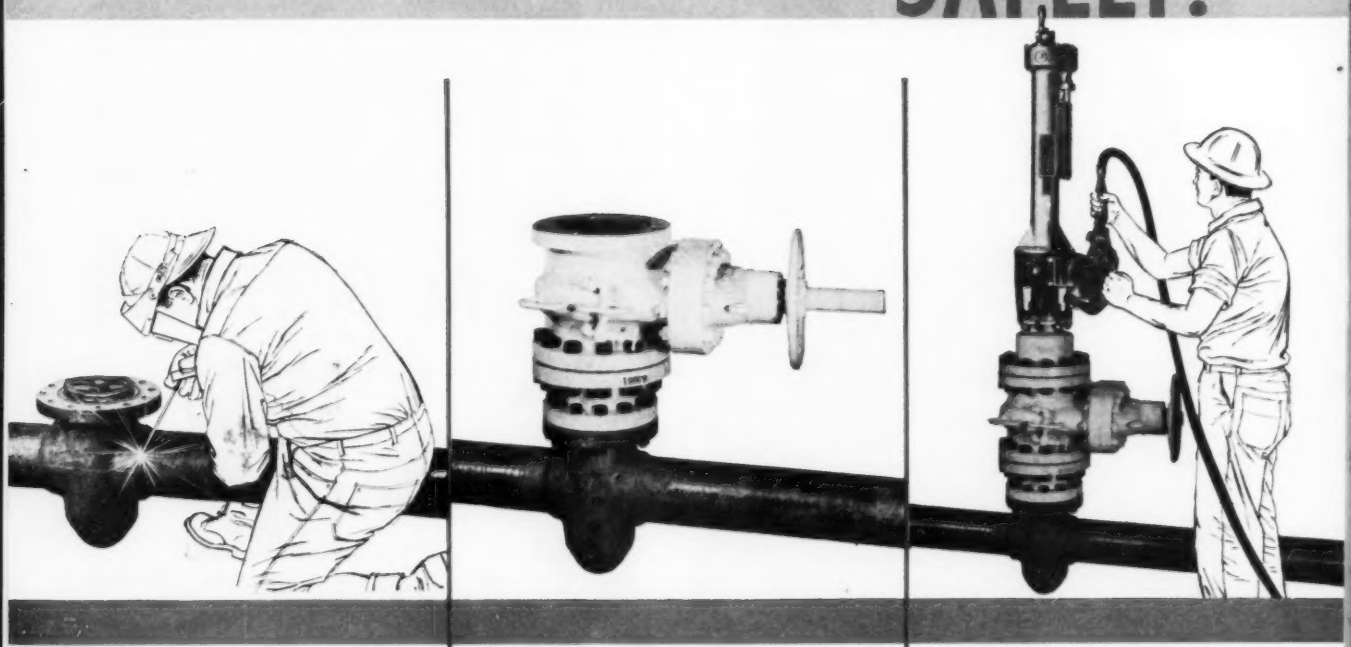
**Pennsalt Chemicals**
ESTABLISHED 1850




For more data on advertised products, use Readers' Service Cards, last page.

# KEEP IT

Tie-in lines and loops
Repair leaks
Remove and install equipment
SAFELY!



**STEP 1** Weld line stopper fittings to piping. Weld Save-A-Valve Drilling Nipples to piping to provide equalizing and purging connections.

**STEP 2** Align special gate valves and bolt securely to line stopper fittings. Attach small gate valves to drilling nipples.

**STEP 3** Bolt drilling machine to valve. Cut out sections of pipe to accommodate stoppers. Close valve and remove machine. Make cuts through drilling nipples.

**MUELLER® NO-BLO® METHOD**

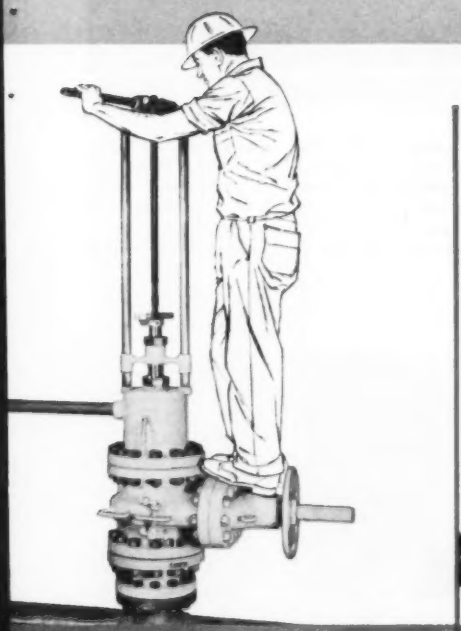
# FLOWING!

■ Just follow this simple step-by-step method for making fast, effective stop-offs with Mueller Line Stopper Fittings and Equipment.

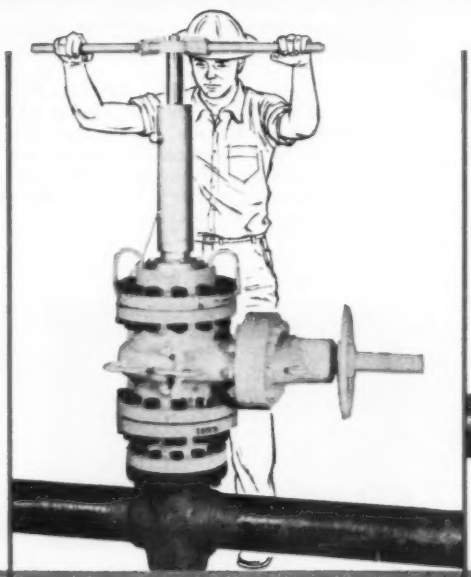
By making two such stop-offs and using a by-pass line, any section of your piping system can be completely isolated without interrupting the flow of fluid.

A by-pass connection built into the body of each Mueller Stopping Machine makes it easy to install a temporary by-pass line with a minimum investment in time and materials.

If desired, a separate by-pass line may be used. Write for complete information.



**STEP 4** Bolt stopping machines to valves. Connect by-pass and equalizing piping and divert flow. Make stop-offs. Section of piping now isolated for repair, replacement or tie-in.



**STEP 5** Close valve and remove stopping machines and by-pass. Install completion plug in top of fittings with completion machine.

**STEP 6** Remove all equipment. Bolt completion caps solidly to line stopper fittings. Cap drilling nipples.

MUELLER CO. Since 1857 SERVING the Water and Gas Industries QUALITY

**MUELLER CO.**
**DECATUR, ILL.**

Factories at: Decatur, Chattanooga, Los Angeles;
In Canada: Mueller, Limited, Sarnia, Ontario.

*Mueller Line Stopper Fittings and Equipment may be used on lines up to 12" in size at pressures as high as 500 p.s.i. on most models and temperatures to 250° F.*

## More Accurate Level Reading of LOW TEMPERATURE LIQUIDS . . .

# JERGUSON

Large Chamber

## NON-FROSTING* GAGES

YOU get the highest possible accuracy of reading on low temperature, low boiling point liquids with the patented Jerguson Non-Frosting Gage in the New Large Chamber model . . . because it insures less turbulence at the meniscus, and clear vision at the vision slot.

This new Jerguson model has 6 times larger area at the meniscus than the standard gage, so that there is a marked reduction in turbulence with light gaseous fluids that tend to boil or surge. Moreover, the problem of frosting encountered with these liquids has been eliminated by a patented frost preventing unit extending from the gage glass. This special transparent unit projects beyond the cover bolts and prevents frost from building up over the vision slot.

Here's a dual feature gage that assures greatly increased accuracy of reading for the process industries. If you have a problem with light gaseous fluids, or with gage frosting, it will pay you to investigate the new Jerguson Large Chamber Non-Frosting Gage . . . reflex or transparent.

*Jerguson Large Chamber Gage, Transparent Type, with the patented Non-Frosting Gage Glass Extension. Write for literature on this gage, and on other non-frosting Jerguson models.*

**Patented*

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

**JERGUSON GAGE & VALVE COMPANY**

**100 Adams Street, Burlington, Mass.**

Offices in Major Cities

Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
Pétrole Service, Paris, France


# Suppliers Notes...

**Six district offices of Armstrong Cork Co.'s Industrial Division have been named to the division's "Twenty Per Cent Plus Club," an exclusive club for offices exceeding their sales quotas by 20 percent or more. Awards were presented by E. W. Jones, field sales manager (center), to (left to right): J. G. Ostertag, manager, St. Louis office; D. M. Smith, Philadelphia office; F. R. Trenor, New York office; P. H. Fiebiger, Los Angeles office; John Mininall, Detroit office and R. L. Fels, Chicago office.**

**Fisher Governor Co. held a three-day 80th anniversary sales meeting in Marshalltown, Iowa, May 23-25, for 150 leading sales representatives from offices throughout the United States, Canada, Mexico and England. Fisher executives presented a thorough picture of the company's current internal progress, after which personnel of technical departments introduced the representatives to coming developments in products, materials and trends. They also showed for the first time new products soon to appear on the market.**

**Woodman**

**Babbitt**

**Shepherd**

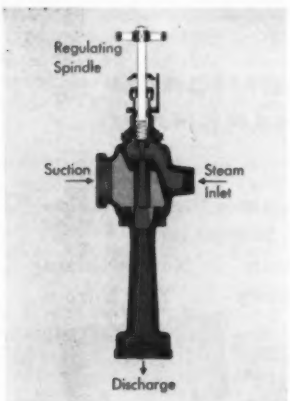
**Ecker**

**CLARK BROS. CO.** has named **Stewart L. Babbitt,** formerly service manager-Houston, sales engineer for the same office. He has been with Clark Service Department since 1949, serving as district service manager in Olean, N. Y., from 1951-57, and as Houston District service manager from 1957 until the present. **G. M. Woodman,** formerly small engine salesman for the Corpus Christ area has been assigned to the Houston District in the same capacity.

**PACIFIC PUMPS, INC.** has named **M. F. Ecker** assistant chief engineer. With the company since 1941, he was in charge of the Tooling Department for a number of years, and then headed research and development operations. For the past eight years he has been assistant chief mechanical engineer. **Wilburn O. Shepherd** has been named senior hydraulic design engineer, and will also supervise the company's testing laboratory. He is a University of California graduate.

# ON THE WAY... SAME DAY

The ejector illustrated in photo and drawing is one variety of SK Steam Jet Exhauster—an air and gas pump which operates on the jet principle using plant steam. As indicated, these units are standard, general-purpose units economically suitable for applications such as pump priming, exhausting, evacuating, cleaning, transporting, compressing, agitating, and general vacuum service. Jet Exhausters are made and stocked in cast iron, stainless steel, Haveg, hard lead, PYREX brand tubing, and impervious graphite in popular sizes, see Data Sheet J-2. They can also be made in bronze, Monel, Everdur, and other machinable materials. In addition to these units, SK also makes a complete line of Steam Jet Vacuum Pumps for providing a range of suction pressures from atmosphere to 25 microns Hg abs. Refer to Bulletins 5E, 5H2, and 5H3 for information on these.




This jet ejector is being shipped from SK stock on the same day the order arrived.

This is *one* of *three* vital reasons why it pays to buy jet apparatus from SK. The others . . .

. . . one, SK pioneered the jet ejector in 1876 and, since then, has accumulated a wealth of valuable data on jet ejector application and performance. Everything we've learned is available to customers.

. . . two, SK has "special material" jet ejector designs unequalled by any other manufacturer. Many are carried in stock. Thus, customers can choose the best material for the job.

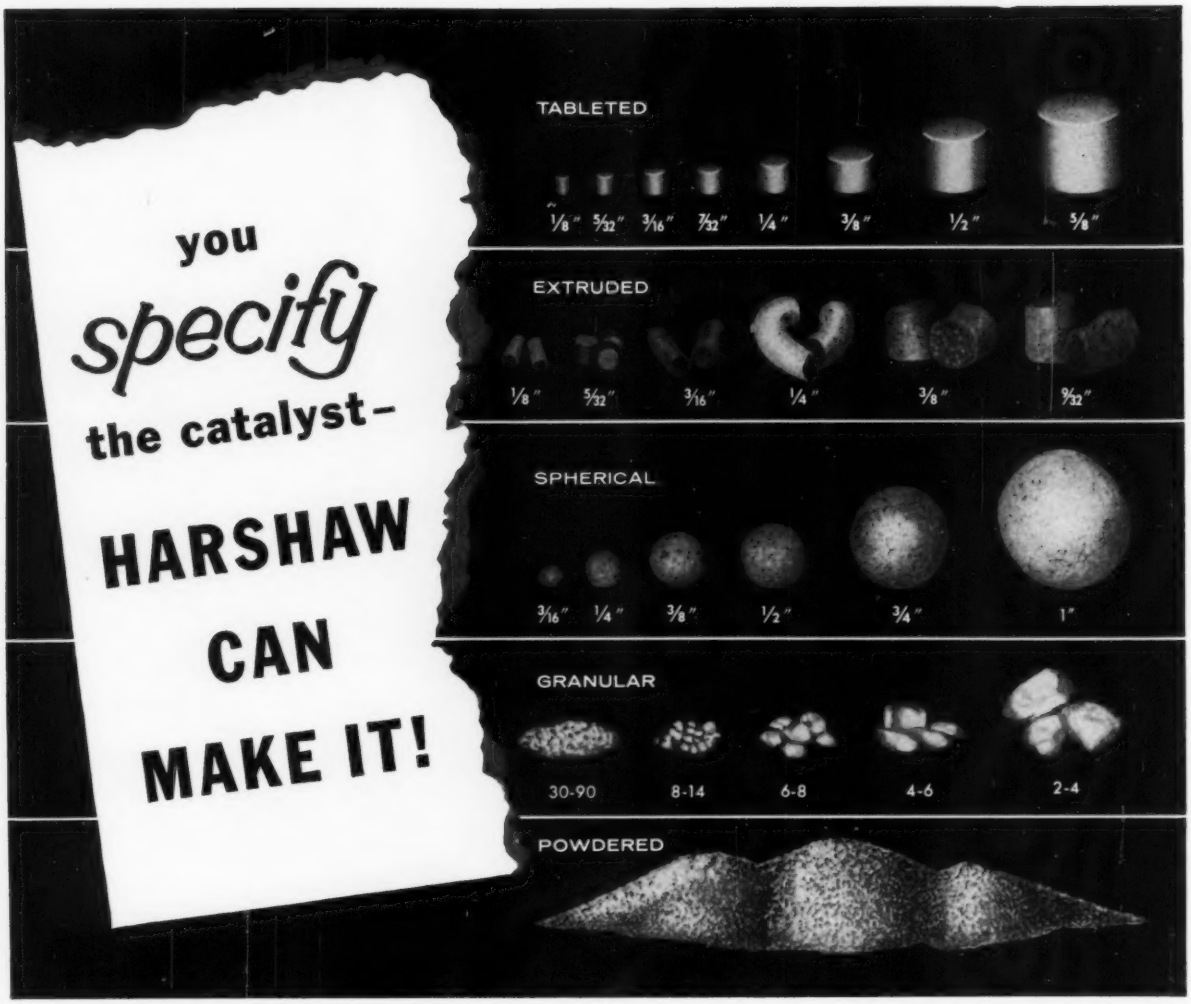
Recently, SK published a data sheet on ejector types, special stock materials, and sizes stocked. It's a valuable addition to any engineer's "source file." Get a copy merely by requesting "Data Sheet J-2."

**For immediate delivery, standard SK Jet Ejectors, Rotameters, and Flow Indicators are stocked in Cornwells Heights (Phila.), Pa., Houston, Texas, and San Francisco, Calif.**

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condens:d Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin G-1.

**Schutte and Koerting**
COMPANY
MANUFACTURING ENGINEERS SINCE 1876
2257 State Road, Cornwells Heights, Bucks County, Pa.
Phone: MErcury 9-0900 TWX: Cornwells, Pa. 69-U


For more data on advertised products, use Readers' Service Cards, last page.




**HARSHAW**

**has the facilities for producing carload quantities of**

**PREFORMED CATALYSTS**

**to fit special process requirements**

| | |
|---|---|
| Hydroforming | Dehydration |
| Cyclization | Desulphurization |
| Oxidation | Alkylation |
| Dehydrogenation | Isomerization |
| Hydrogenation | |

## CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate — Cobalt Nitrate
Copper Nitrate — Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)
Nickel Carbonate — Nickel Formate — Nickel Nitrate
Nickel Sulfate — Sodium Methoxide — Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

***Write for FREE Booklet, "HARSHAW CATALYSTS"***

HARSHAW

**THE HARSHAW CHEMICAL CO.**

**1945 EAST 97th STREET • CLEVELAND 6, OHIO**

**Chicago • Cincinnati • Cleveland • Hastings-On-Hudson, N.Y. • Houston • Los Angeles**
**Detroit • Philadelphia • Pittsburgh**



For more data on advertised products, use Readers' Service Cards, last page.

## *Suppliers . . .*

**CONOFLOW CORP.** has named **Fred H. Sandritter** assistant advertising manager. He joined the company in 1955 as an Advertising Department assistant. In 1959 he was named supervisor, Direct Mail Section, which position he held until his present appointment. After receiving his B.B.A. degree from Pennsylvania State University in 1952 he entered the U. S. Air Force. Following discharge, he attended the Charles Morris Price School of Advertising and graduated with highest academic honors in 1958.

Sandritter

**THE TIMKIN ROLLER BEARING CO.** has elected **W. R. Timkin** president succeeding **D. A. Bessmer,** who has retired because of ill health. With the company since 1935, Timkin is a graduate of Harvard University.

**FOOD MACHINERY AND CHEMICAL CO.** has named **Glenn A. Farno** sales manager of chemicals, Chemicals & Plastics Division. Previously a sales representative for the division, Farno joined the company in 1952.

**RAYMOND INTERNATIONAL, INC.** has elected **George F. Ferris** chairman of the board and **Henry C. Boschen** president. Ferris joined the company in 1946 as vice president and general manager. Boschen has been with Raymond since 1928.

**BORG-WARNER CORP.** has elected **Franklin Sloff** assistant controller. To headquarter in Chicago, Sloff was formerly treasurer and controller of the company's Jackson Division. He has been with Borg-Warner since 1956.

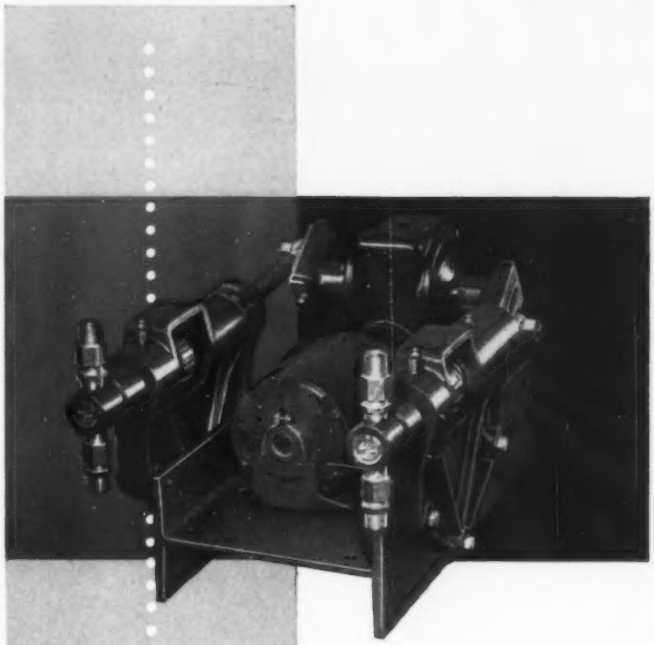
**SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.** has appointed **Robert O. Vaughan** vice president of marketing. He was formerly Western Region manager of government operations for Dresser Industries, Inc.

**THE BRIGGS FILTRATION CO.** has named **Walter E. Yedlinsky** representative for industrial sales in Western Pennsylvania. A graduate of New York University, and a registered professional engineer, he was formerly with Westinghouse.

**INFILCO, INC.** has named Robert R. Alpen Industrial Equipment, Ltd., West Vancouver, B. C., as agent in British Columbia. Infilco operations in the area will be managed by **Robert Alpen,** president.

**HEYDEN NEWPORT CHEMICAL CORP.'s** Heyden Chemical Division has named **Robert M. Aude** president. Since 1958 he has been the division's vice president and general manager. Aude has been with the firm since 1953.


POSITIVE CONTROL OF MATERIALS IN MOTION BIF METERS FEEDERS CONTROLS



**ONE PUMP PROPORTIONS ALKALINE, NEUTRAL OR ACID CHEMICALS**

BIF *Proportioneers* **Adjust-O-Feeder**

**Gives Application Versatility At Low Initial Cost**

Meet changing requirements without changing your entire pump! Low cost changeover, with plug-in reagent ends, makes Model 1140 Proportioneer® extremely versatile in the capacities and types of chemicals it can handle. Compare these performance characteristics with competitively priced pumps:

*Accuracy within ±1% of set rate.*
*Adjustment range of 15:1 (not 10:1 as most).*
*Capacity from 0.8 gph to 850 gph.*
*Discharge pressures up to 1340 psig.*

You'll find opportunities for cutting costs and improving efficiency in process feeding when you consult B-I-F — manufacturer of the most complete line of solid and liquid feeders.

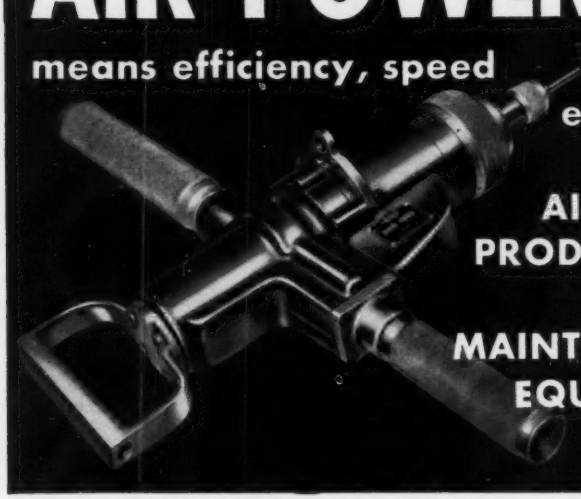
B-I-F *Industries*

BUILDERS-PROVIDENCE • PROPORTIONEERS • OMEGA
METERS • FEEDERS • CONTROLS / CONTINUOUS PROCESS ENGINEERING

For complete details on Model 1140 request Bulletin 1140.20-1. Write **B-I-F Industries, Inc., 412 Harris Ave., Providence 1, R. I.**

# AIR POWER

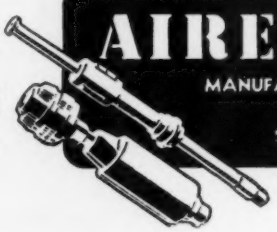
means efficiency, speed and economy with AIRETOOL PRODUCTION and MAINTENANCE EQUIPMENT



AIRETROL Tube Expansion Control for fast, precision tube rolling. Rugged air-motor drive speeds operation and an automatic torque sensing control stops expansion within .001 inch of predetermined setting. Lightweight and easy to handle. Permits one man to roll 12 tubes a minute.

MODEL CC-475 heat exchanger and condenser tube cleaner. Weighs just 11 pounds for easy one-man operation without supporting rig. Air-motor driven to deliver all the power needed for cleaning clogged tubes up to 1 inch in diameter. Built-in flushing system keeps drill head cool and tubes clear.

Into every piece of Airetool pneumatic equipment goes more than 30 years' experience in pioneering design and development of powerful, efficient air-motors. The result is a complete line of performance-proven pneumatic tools that help speed fabrication, assembly operation and maintenance with substantial savings in costs. Airetool equipment is engineered for fast, easy handling that permits the operator to work faster over longer periods without tiring. Write today for information on Airetool's full line of pneumatic production and maintenance tools that includes drills, screwdrivers, nutsetters and grinders.



AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

**BRANCH OFFICES:** New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge
**REPRESENTATIVES:** in principal cities of U.S.A., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii
**CANADIAN PLANT:** 37 Spalding Drive, Brantford, Ontario
**EUROPEAN PLANT:** Vlaardingen, The Netherlands


## *Suppliers . . .*

**WORTHINGTON CORP.'s** Mason-Neilan Division has named **Eric A. Bianchi** general manager. An MIT graduate, he has been vice president, engineering and manufacturing, of Mason-Neilan Division since 1956, when it became an operating division of Worthington. Before that, he had been director of engineering for the Mason-Neilan Regulator Co. He has been a director of Worthington—Canada since 1958. Bianchi is a member of SAMA and is vice president of the Fluid Controls Institute. He was recently named to the executive board of the Boston branch, National Metal Trades.

Bianchi

**CONOFLOW CORP.** has named E. N. Murray Co. manufacturers' representative, Denver. The firm will be Conoflow's exclusive representative in Colorado and Wyoming. Murray company is operated by **Earl N. Murray** and **John M. Hunt.**

**PETROLITE CORP.** has won the Award of Merit presented by the National Safety Council. The award was given for the firm's safety record in the chemical industry during 1959. Its basis included all personnel and all divisions.

**THE CARPENTER STEEL CO.** has elected **Guido F. Verbeck, Jr.,** to its board of directors. He also assumes the same position with Carpenter Steel of New England, Inc. Verbeck is senior vice president, Morgan Guaranty Trust Co.

**BECKMAN INSTRUMENTS INC.'s** Scientific and Process Instruments Division has named **Herbert Feitler** product line manager. He will direct sales and product planning of Beckman's laboratory.

**WOLVERINE TUBE DIVISION** has appointed **Travis E. Mosier** sales representative in Moline, Ill. Formerly with the General Sales Office, Allen Park, Mich., his territory will include Eastern Iowa and Northwestern Illinois.

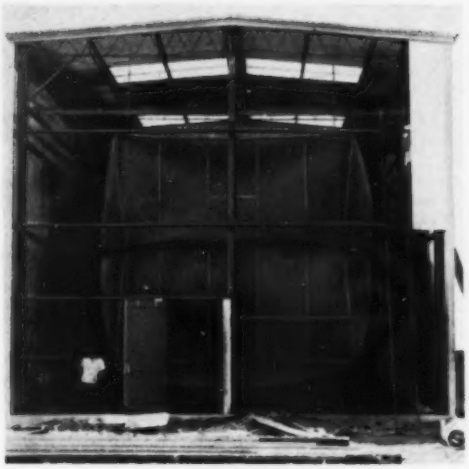
**THE CLEVELAND CRANE & ENGINEERING CO.'s** sales activities have been consolidated into one Sales Department under **Robert G. Birkin,** general sales manager and **J. G. Frischkorn,** sales manager.

**BORG-WARNER CORP.'s** Ingersoll Products Division has appointed **Michael J. Vovata** sales manager for the EMCOR Ingersoll Products Division. He was formerly sales supervisor at EMCOR.

**UNITED STATES GASKET CO.** has named **Charles C. Colozzi** president and a member of the board. He studied engineering at Pennsylvania, Temple and Rutgers universities, and has been with U. S. Gasket since 1953.

**PACIFIC PUMPS, INC.** has named **Doran B. Harney** chief engineer. He joined Pa-

# BIG SAVINGS WITH LOW-COST REEVES-VULCAN BREATHER BALLOONS



**Stop vapor loss with this air-tight, self-contained, completely closed system.**

Now—with a low-cost Breather Balloon installed in new or modified storage systems, you can capture the vapors that might otherwise be lost during the storage or transfer of volatile liquids. Reeves-Vulcan Breather Balloons require no skilled labor to install, no high priced housing . . . cost practically nothing to maintain.

Ultra-high strength neoprene-coated nylon gives these rugged balloons unusually long life. Every Breather Balloon installed is still in use, still returning profits. Make your storage tank a closed system . . . install Reeves-Vulcan Breather Balloons—the most efficient and most economical system of vapor conservation ever developed for low to medium storage volume.

For free, informative brochure, write to: Reeves Brothers, Inc., Vulcan Rubber Products Division, 1071 Avenue of the Americas, New York 18, New York.

**REEVES** VULCAN

Reeves Brothers, Inc., Vulcan Rubber Products Division
1071 Avenue of the Americas · New York 18, New York

Don't take our word for it—try a new RIDGID Flaring Tool! See if you don't get smoother, stronger, more uniform flares . . . in less time and with less effort than ever before!

Then, compare this new RIDGID Flaring Tool, feature-by-feature, with any flaring tool you've ever seen or owned:

• Feed releases automatically when flare is fully formed. • Reversing feed screw burnishes flare. • Hardened steel die bars are precision-machined. • Large, comfort-grip feed screw handle turns easily. • Precision-ground, hardened steel flaring cone, eccentrically mounted in precision bearings, produces rolling action for even metal flow . . . gives uniform flare walls without galling. • Tubing hole sizes are clearly marked. • Easy sliding rugged malleable yoke serves as stop for tubing to give correct flare size. • Yoke clamp screw fits into centering hole . . . locks bars, yoke and tubing into perfect alignment. • Stop pins keep yoke on die bars at all times . . . yoke can't slide off.

**3 MODELS:**

RIDGID No. 457 for 45° flares, ⅛″ to ⅝″ O.D. (7 sizes)
RIDGID No. 459 for 45° flares, ⅛″ to ¾″ O.D. (9 sizes)
RIDGID No. 376 for 37° flares, 3/16″ to ⅝″ O.D. (6 sizes)

See and try these new RIDGID Flaring Tools.
Your Supply House has them.

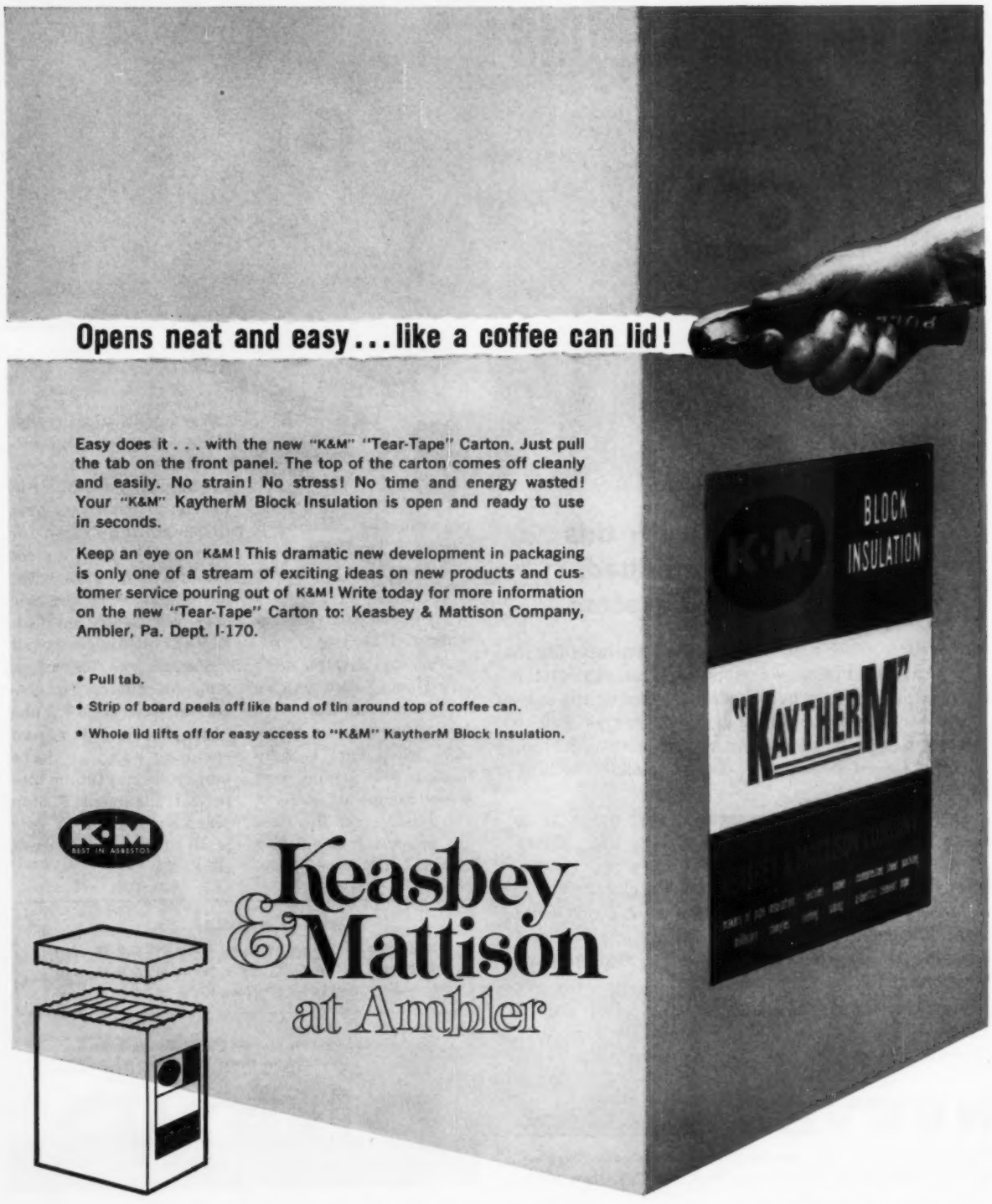
RIDGID
The Ridge Tool Company · Elyria, Ohio, U.S.A.



For more data on advertised products, use Readers' Service Cards, last page.

**Now, the first "quick open" package for insulation products...**

# "K&M" TEAR-TAPE CARTON


Opens neat and easy...like a coffee can lid!
Easy does it . . . with the new "K&M" "Tear-Tape" Carton. Just pull the tab on the front panel. The top of the carton comes off cleanly and easily. No strain! No stress! No time and energy wasted! Your "K&M" KaytherM Block Insulation is open and ready to use in seconds.
Keep an eye on K&M! This dramatic new development in packaging is only one of a stream of exciting ideas on new products and customer service pouring out of K&M! Write today for more information on the new "Tear-Tape" Carton to: Keasbey & Mattison Company, Ambler, Pa. Dept. I-170.
• Pull tab.
• Strip of board peels off like band of tin around top of coffee can.
• Whole lid lifts off for easy access to "K&M" KaytherM Block Insulation.
K·M
BEST IN ASBESTOS
Keasbey & Mattison at Ambler
BLOCK INSULATION
"KAYTHERM"

## Suppliers . . .

cific Pumps in 1940 after graduation from the University of California in 1940, and has served in various capacities in the Engineering Department ever since.

**HEIDRICK AND STRUGGLES, INC.** has named **Dr. Robert C. Zabor** an associate. He joins the executive recruiting firm from Gulf Research and Development Co. Dr. Zabor, a chemistry graduate of Williams College, with a Ph.D. degree in physical chemistry from the University of Pittsburgh, engaged in fundamental studies for five years before assuming research supervision and administration in both fundamental and applied phases of process and product research in the petroleum and petrochemical industries. He is a member of ACS, Sigma Xi, Phi Gamma Delta, and Phi Beta Kappa.

Zabor

**WOLVERINE TUBE DIVISION** has named **Edward F. Sweeney** sales representative for Kansas and Western Missouri. Having spent the past five years as District Sales Representative in this area, he replaces **J. P. Moore,** who will take up a new territory in Seattle.

**BAIRD-ATOMIC, INC.** has enlarged its Spectrochemical Division staff with the addition of three new sales engineeers—**Bernard C. Lindstrom, Richard P. MacCarthy** and **James J. Matthews, Jr.**

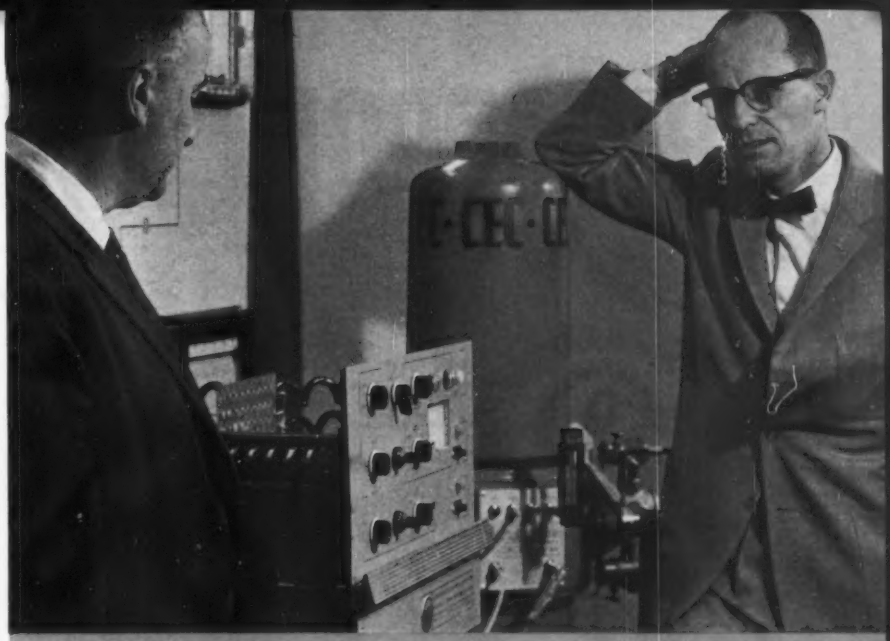
**MALCOLM D. DUNCAN & ASSOCIATES** has been named by Mason-Neilan Co. to represent the company in South Georgia and the Florida Peninsula. Duncan will operate out of Jacksonville, Fla., headquarters.

**JONES & LAUGHLIN SUPPLY DIVISION** has named **J. K. Robinson** resident salesman at Okmulgee, Okla. With the company since 1936, he served for a year as a storeman at Hobbs, N. M., before going to the Okmulgee store.

**BUELL ENGINEERING CO.** has elected **Jack L. Schumann** president and director. He joined the company in 1946 as a sales engineer. Ten years later he joined Vitro Engineering Co.—and later became vice president.

**UNITED STATES TESTING CO.** has appointed **Dr. Robert C. Putnam** chief chemist. His duties will include supervision of the Chemical Division, with emphasis on research and development programs.

**MINNEAPOLIS-HONEYWELL REGULATOR CO.'s** Rubicon Division has named **Charles S. Marshall** manufacturing superintendent. With the firm since 1951, he has had various assignments in industrial engineering and manufacturing quality control.

# LOOK INTO CEC's NEW PROCESS CHROMATOGRAPH

## *. . . for at least four advantages you won't find in other instruments*

**Here are just four of the reasons why CEC's 26-212 High-Speed Process Chromatograph is the most advanced instrument of its kind. You'll find the 26-212 unique because it offers:**

**EXTREME FLEXIBILITY. The analyzer accommodates all types and sizes of columns, multiple columns and a variety of detectors. Programming changes for new applications also can be made easily in the field.**

**HIGH SPEED. The 26-212 is the only multiple-stream, high-speed chromatograph on the market. It's 10 to 40 times faster than conventional units...makes many analyses in just 20 to 30 seconds.**

**DUAL-ZONE TEMPERATURE CONTROL. Sample metering at temperatures up to 220°C (428°F), and column operation at lower temperatures permits precision analysis of high-boiling, high-endpoint streams.**

**AUTOMATIC PROCESS CONTROL. Precision, high-speed operation makes possible closed loop pneumatic, electronic, and computer control of rapidly changing petroleum, petrochemical, chemical, and pharmaceutical processes.**

***The 26-212 is easily serviced in the field. All parts are readily accessible and require no routine maintenance. For more information on this unique new process chromatograph, call your nearby CEC sales and service office or write for Bulletin CEC 1860-X5.***

*Analytical & Control Division* CEC

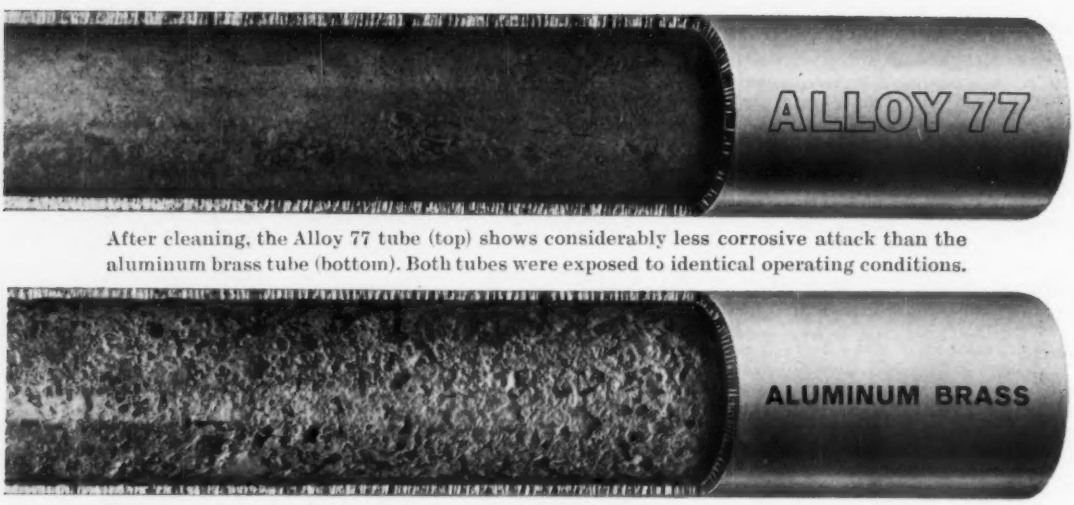
CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell · FINER PRODUCTS THROUGH IMAGINATION

# BRIDGEPORT ANNOUNCES

# ALLOY 77*

## *new condenser tube alloy radically reduces biofouling*




After cleaning, the Alloy 77 tube (top) shows considerably less corrosive attack than the aluminum brass tube (bottom). Both tubes were exposed to identical operating conditions.

Metallurgical history is being made by Bridgeport's use of Mercury as the corrosion inhibitor in Alloy 77, the first completely new condenser-tube alloy developed in years. Startling advantages for this alloy have been uncovered during 18 years of continuous laboratory and field service tests.

Alloy 77 does what has never been done before in the control of biofouling. The Mercurial Brass Alloy kills living biorganisms before they have a chance to attach themselves to tube interiors. Costly chlorination treatments are reduced and no unusual cleaning methods are needed.

Chlorine Dollars, Cleaning Dollars, Lost Heat Transfer Efficiency Dollars can be saved when you tube or retube with Bridgeport Alloy 77. Full details can be had immediately from our Technical Data Folder. A request to Dept. 5307 for "77" will get you your copy.

*U.S. Patent No. 2,887,374, May 19, 1959

**The advantages of Alloy 77 have been proven time and again in sea water, fresh water and brackish water. Check these advantages:**

1. **Radically reduced biofouling**
2. **Higher transfer efficiency**
3. **Excellent general corrosion resistance**
4. **Forms soft, thin, powdery scale**
5. **Simple, easy cleaning**
6. **Field tested performance**

**BRIDGEPORT BRASS COMPANY**

*Bridgeport 2, Connecticut* — *Specialists in Metals from Aluminum to Zirconium*

## *Suppliers . . .*

**PENNSALT CHEMICALS CORP.** has named **John M. French** manager of development, Corrosion Engineering Products Department. With headquarters in Natrona, Pa., he will be responsible for research and development for new products. French, who holds a B.S. degree with honors in chemistry from Duke University and a M.S. degree in chemical engineering from Columbia University, has been in chemical research and technical service since 1941. For the past 12 years he was with E. I. duPont de Nemours & Co. at various DuPont locations.

French

**REGAN INDUSTRIES, INC.** has elected **Bert I. Graves** a director. He is president and founder of B. I. Graves Associates, San Francisco petroleum consultants. He was with Tidewater Oil Co. before organizing his own firm in 1953.

**HYDRODYNAMICS, INC.,** Silver Spring, Md., has been organized as a subsidiary of American Instrument Co., Inc. **Leopold Freeman** is board chairman and president of the new firm and **C. E. Ohlheiser** is general manager.

**COOPER ALLOY CORP.** has appointed **Michael DePiano** sales manager, Valve and Fitting Division. **Clayton L. Heintz,** DePiano's predecessor, will represent the division in the Philadelphia area.

**HAVEG INDUSTRIES, INC.** has completed new research and development laboratory facilities in Taunton, Mass. The company believes it to be "the largest facility of its kind in the plastics molding and fabricating industry."

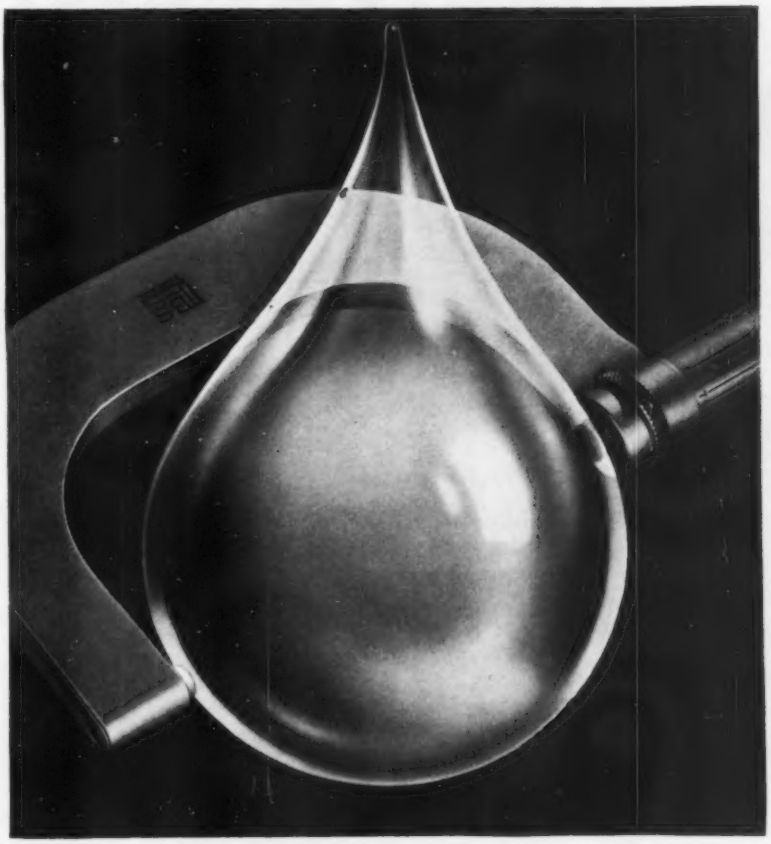
**BORG-WARNER CORP.'s** EMCOR Ingersoll Products Division has named J. A. Reagan Co., Albany, N. Y., engineering-sales representative in upper New York. The new representative will service industrial and electronic accounts.

**MECHANICAL AIR CONTROLS, INC.** has named as distributors for its line of air valves, Automation Equipment & Supply Co., Pittsburgh; Stewart-Hunt, Inc., Lexington, Mass.; Goll-Hanford Corp., Buffalo, N. Y.; and Leo J. Schindler Co., Dallas.

**OAKITE PRODUCTS, INC.** has appointed **Daniel B. Lamb** manager, Detroit Division. He replaces **T. R. Smith** who is retiring after 33 years with the company and 19 years as head of the Detroit Division.

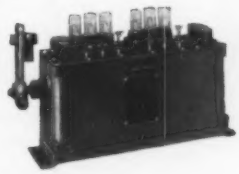
**SUMNER SOLLITT CO.** has named **H. H. Dronberger,** to a position in its Engineering Department. He was formerly manager of the Toledo refinery of The Pure Oil Co.


# How ACCURATE



# can an oil drop get?

Precise and punctual is the best way to describe an oil drop metered by a Manzel force-feed lubricator. Model "82", for example, will deliver an exact amount of oil exactly where it belongs at exactly the right point in the cycle of your mechanism. The positive sight feed shows you the oil on its way to work *after* it's passed through the pump. Our Model "82" is built for pressures up to 6000 PSI and "round the clock service"! For details on "82" or any of our complete line of lubricators, write for our catalog. Manzel, 256 Babcock Street, Buffalo 10, New York. To lubricate with mathematical precision, just



**ask the man from**

A UNIT OF HOUDAILLE INDUSTRIES, INC.

**Manzel**

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898



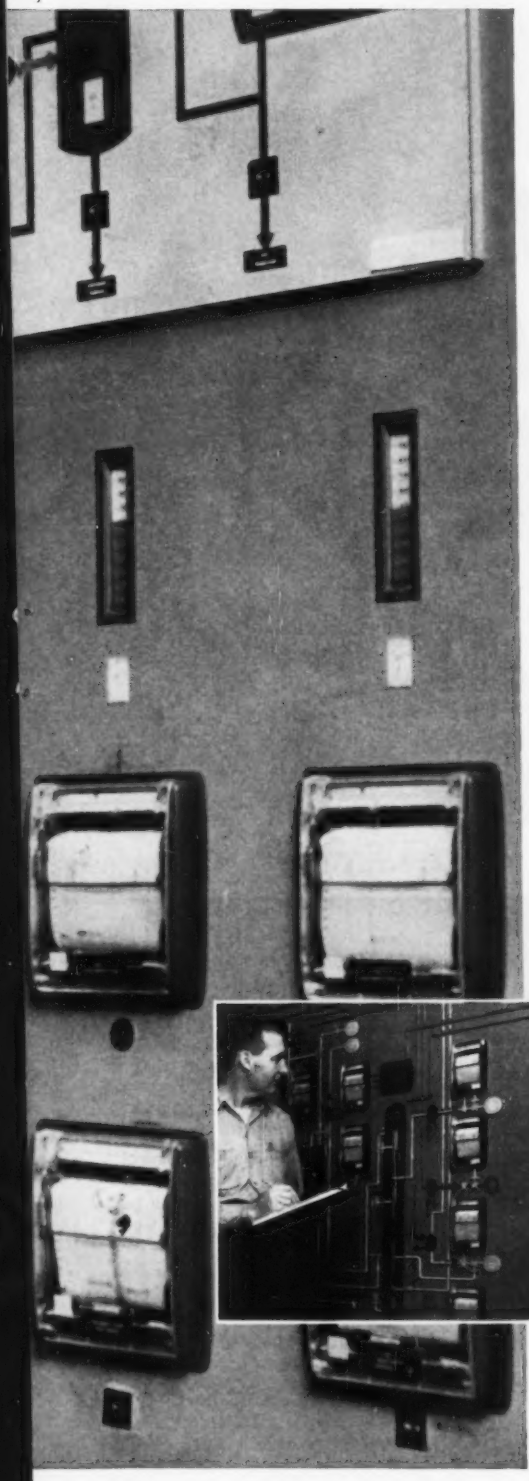

For more data on advertised products, use Readers' Service Cards, last page.

# Esso looks to

Consotrol Control panel for Powerformer* at Esso's Bayway Refinery, Linden, New Jersey. Complete Consotrol Control Station slides out from front of panel as a unit — makes servicing easier for Esso technicians.

*Trade mark, Esso Standard Oil Company

# Consotrol* instruments



## for dependable control at their Bayway Refinery

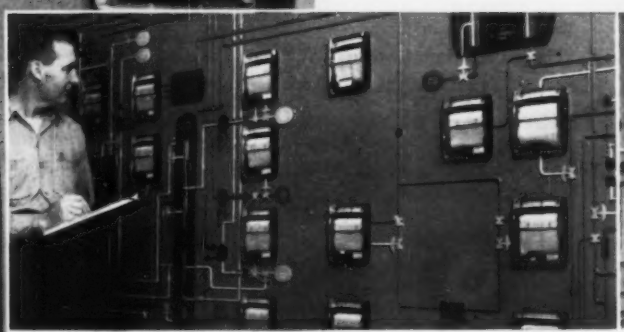
Precise, dependable, centralized control . . . full-scale, easy-to-read chart records . . . simplified maintenance from the front of the panel. No wonder leading refineries like Esso specify Foxboro pneumatic Consotrol instrumentation.

Consotrol control stations are so compact, four can fit where one circular chart instrument used to go. Yet recorders still have a full-scale, 4-inch chart — can furnish continuous recording of up to 3 different variables on the same chart.

Consotrol M/58 Controllers handle a full-range of control functions: auto-selector . . . cascade and ratio systems . . . automatic batch control.

Get the complete story on pneumatic Consotrol instrumentation by writing for Bulletin 13-18. **The Foxboro Company, 747 Neponset Ave., Foxboro, Mass.**

*Reg. U.S. Pat. Off.



▲ Foxboro control panel for #6 Pipe Still was installed in 1952. Consotrol recorders have a full-scale 4" chart which travels vertically. Pen arm moves in an arc — eliminates extra linkage common to instruments that must convert rotary motion to straight-line pen travel.

▲ This hydrofiner full-graphic panel includes 54 Consotrol Recorders, 44 Controllers. Ethylene Plant control panel (not shown) includes another 100 Foxboro pneumatic Consotrol instruments.

FOXBORO

REG. U.S. PAT. OFF

**The pump must match the application**

The available range of our RPK Process Pumps offers the Oil Industry a selection that fully meets the fundamental requirement stated above.

The special characteristics of this pump are maximum reliability and economical operation at all operating points. Other features are the wide range of capacities and applications, the ease with which erection and disassembly can be carried out, and parts subject to wear renewed. The design includes a high factor of safety.

The parts particularly liable to deteriorate by wear are standardized for the widest possible range of sizes, and thus the maintenance of an adequate stock of spares is greatly facilitated.

Every type of service is catered for in respect of shaft sealing, which may be by means of the conventional packed stuffing-box or one of a great variety of mechanical seals.

**KSB**

**Klein, Schanzlin & Becker Aktiengesellschaft, Frankenthal (Pfalz) Germany**



For more data on advertised products, use Readers' Service Cards, last page.

## *Suppliers . . .*

**RAWSON & CO., INC.** has opened a sales and service office in Beaumont, Texas, under the direction of **William S. Knoble.**

**Knoble**

His experience includes seven years at the Mobil Beaumont refinery in the Technical and Engineering Department where he worked on such commercial units as MEK dewaxing, furfural extraction, alkylation and pipe stills. Knoble graduated from the U. S. Naval Academy in 1949 and joined Mobil after military service.

**SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.** has appointed **Robert O. Vaughan** vice president of marketing. Formerly Western Region manager of government operations for Dresser Industries, Inc., he will headquarter in Houston.

**GOODYEAR TIRE & RUBBER CO.'s** Hose Sales Department has promoted **James A. Bailey, Jr.,** to assistant manager. **Donald E. Harrington** will replace Bailey as manager of hydraulic hose sales.

**A. M. BYERS CO.** has named **A. H. McArn** to a position in its Engineering Service Department. Holder of a B.S. degree in electrical engineering from Carnegie Institute of Technology, he was previously with Union Switch & Signal Co.

**STRAND-STEEL CORP.** has appointed **J. G. Skaaren** assistant to the president. He has been with the company 15 years—first as manager, Minneapolis Sales Territory, and eventually as general sales manager.

**T. SHIVER & CO.** has named Western Sales Engineers, Inc., Los Angeles, as its sales agent in California, Oregon and Washinton. Five of the company's sales engineers will operate out of offices in Los Angeles, Oakland and Seattle.

**BECKMAN INSTRUMENTS, INC.'s Dr. Arnold O. Beckman,** president of the company, has received an Illini Achievement Award for "leadership in the field of precision instruments." He was one of three to receive the University of Illinois award.

**HARNISCHFEGER CORP.** has named Maquinas y Herramientas Sabin St. Germain, S. A., Mexico City, distributor for electric hoists and overhead traveling cranes. The firm will cover Southern Mexico.

**THE BENDIX CORP.'s** Bendix Filter Division has appointed **Brian A. Wilson** manager, Western Region. He will be responsible for marketing efforts in the Western United States. Wilson will headquarter in Van Nuys, Calif.

**DORR-OLIVER, INC.** has transferred **Robert E. Hochscheid** from Johannesburg, South


*Absolute Line Shut-off*

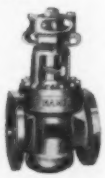
**BY ONE MAN – IN ONE MINUTE!**

**HAMER** *Visible Shut-off*

**LINE BLIND VALVES**

**HAMER PLUG VALVES**

Will not stick or freeze. Perfect for hard-to-hold fluids. Simple plug adjustment nut eliminates sticking



Hamer Line Blinds are unsurpassed for positive action, easy operation, long-life service and lasting safety. One man can open or blind a line in less than one minute, and there is nothing like a solid plate for a PERMANENT LEAKPROOF SHUT-OFF. Bar or handwheel operation eliminates wedges, hammers, wrenches needed for spreading conventional flanges. Removes fire hazard of sparking and stops damage to equipment.

***Write for FREE catalog***

**Hamer** VALVES

*MANUFACTURED AND SOLD BY*

**WELL EQUIPMENT MFG. CORP.**

HOUSTON, TEXAS

Division of CHIKSAN COMPANY *a subsidiary of* FOOD MACHINERY AND CHEMICAL CORPORATION

fmc

WECO




For more data on advertised products, use Readers' Service Cards, last page.

## *Suppliers . . .*

Africa, to a new office in Santiago, Chile, as technical representative. He will serve customers in Ecuador, Bolivia, Peru and Chile.

**TUBE TURNS PLASTICS, INC.** has expanded its Louisville, Ky., plant to increase manufacturing, raw material and warehouse space by about one third. The main unit in the expansion is a one-story steel and masonry building.

**CONTINENTAL-EMSCO CO.** has opened new quarters for its Lake Charles, La., supply store. **Nealy Nevils, Jr.,** is manager of the store, which is under the supervision of **E. A. Dunn,** New Orleans office.

**NATIONAL FOAM SYSTEM, INC.** has disposed of its interest in National Fire Protection Co. The new owner of the firm is M. L. Snyder & Son, Inc., Philadelphia. Other National Foam operations are not affected.

**J. I. CASE CO.** has named **Leon T. Newman** treasurer succeeding **William B. Peters,** who has retired after 50 years with the company. Newman has been with Case since 1946.

**KAISER STEEL CORP.** has opened a sales office in Albuquerque, N. M., to be headed by **Keith W. Meserve,** who has been transferred from the company's Denver sales office. He has been with Kaiser since 1955.

**BENNETT INDUSTRIES, INC.** has elected its former president, **Stevens A. Bennett,** chairman of the board. **Anthony J. Gasbarra,** formerly executive vice president, has been named president.

**W-K-M DIVISION** of ACF Industries, Inc. has appointed **Glen Tableman,** a 10-year company veteran, manager of sales, and **Paul J. Natho** manager, Market Development Department.

**H. K. PORTER CO., INC.** has started a $4-million construction and equipment modernization program at the Bessemer, Ala., and Wellsville, Ohio, plants of its Refractories Division. Major items will include three new tunnel kilns.

**THE BABCOCK & WILCOX CO.'s** Tubular Products Division has announced the retirement of **Leon E. Jeanneret,** manager of welded tubing sales. With the company 43 years, he is a graduate of Columbia University.

**JAEGER-CORDRAY, INC.,** Orlando, Fla., has been appointed representative for the Southeastern Region, Southwestern Industrial Electronics Co. To operate in Alabama, Georgia, and Florida, the firm is directed by **Don Jaeger.**

**GENERAL ELECTRIC CORP.'s** Distribution Assemblies Department has named **Alfred J. Carletti** manager of headquarters manufacturing. With the company since 1941, he has held a number of manufacturing assignments.

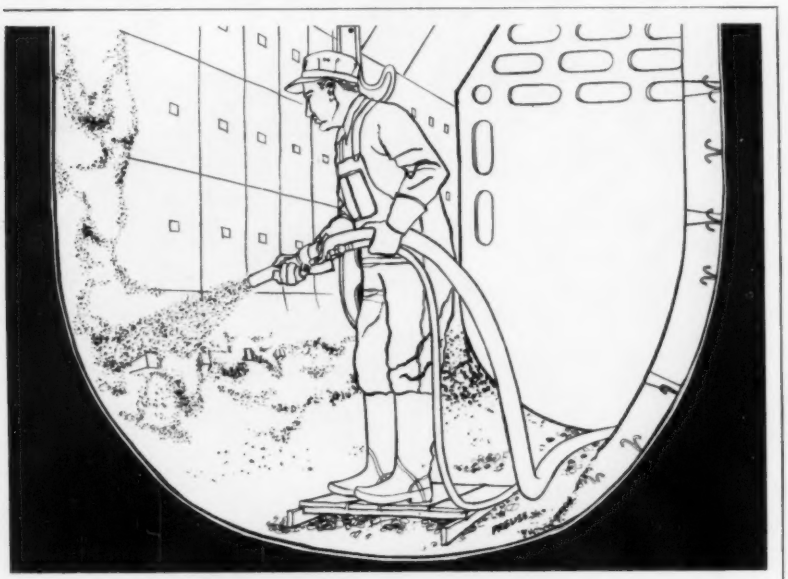
**BECKMAN INSTRUMENTS INC.'s** Scientific and Process Instruments Division has named **Richard C. Erbes** customer relations manager. He will direct the division's training and service programs, and guide management-dealer relations.

**BARRY CONTROLS, INC. AND THE WRIGHT LINE, INC.** have recommended to their stockholders that there be a merger of the two companies. Shares would be exchanged on a shore-for-share basis for stock of the consolidated firm.

**BETHLEHEM STEEL CO.** has named **E. R. Phillips** regional manager, Rocky Mountain Region. Since January, he has been assistant to the regional manager, Southwestern Region. Phillips will headquarter in Denver.

**GENERAL MILLS CO.'s** Mechanical Division has appointed **George Strawn** manager, Western Region. He will headquarter at Redondo Beach, Calif. Strawn will be responsible for company relations with government and industry within the region.

**UNION PUMP CO.** has opened offices in Oakland, Calif. **Dean DeGraffenreid** has been named district manager and will provide sales liaison to industries throughout Northern and Central California.

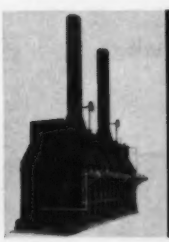
# EVEN AMONG SPECIALISTS, SOME STAND OUT!

To assure complete insulation, the fire box on all UNI-RAD Process Heaters is lined with pneumatically applied insulating concrete and fire brick. This insulation plus the unique arrangement of burners and tubing within the fire box have gained for Anderson thermal design specialists wide recognition in the petroleum processing and chemical industries.

Uniform radiation — UNI-RAD — supplies more heating power at less cost by providing optimum heat recirculation.

Maintenance presents no problem as all standard parts are easily replaced. A full-time staff of Anderson service engineers is ready to assist you at any time.

For quality heating equipment, you can rely on UNI-RAD!



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## SAVE ESTIMATING TIME

**Now . . .** a Labor Estimating Library that will help you slice estimating time to a minimum, while maintaining maximum accuracy.

The scores of manhour tables in each manual contain literally thousands of easy-to-use listings. These listings are valuable guides to estimating manhours in every phase of piping, electrical or general construction installation and fabrication. They are the result of hundreds of time-and-method studies, coupled with actual labor costs on numerous projects.

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By JOHN S. PAGE and JIM G. NATION

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### *Estimator's Electrical Manhour Manual*

By JOHN S. PAGE and JIM G. NATION

Price **$10.00**

Areas covered in 15 Sections include: Conduit, Boxes and Fittings; Service and Feeder Wiring; Branch Circuit Items; Light Fixtures; Panelboards and Cabinets; Safety Switches; Hangers and Fasteners; Underfloor and Buss Ducts; Starters and Motors; Mounting Transformers; Outside Construction; Underground Duct and Cable; Communication and Signal Systems; Demolition; Excavation and Concrete; Technical Information.

### *Estimator's General Construction Manhour Manual*

By JOHN S. PAGE

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Areas covered in 18 Sections include: Demolition; Site-Grading and Structural Excavation; Concrete Roadways; Sheet and Foundation Piling; Formwork; Reinforcing Steel and Mesh; Miscellaneous Embedded Items; Concrete; Masonry; Structural Steel and Miscellaneous Items; Carpentry and Millwork; Metal Doors; Sash Glass and Glazing; Special Flooring; Special Walls and Ceilings; Roofing and Siding; Ornamental Metal and Special Partition; Painting; Miscellaneous.

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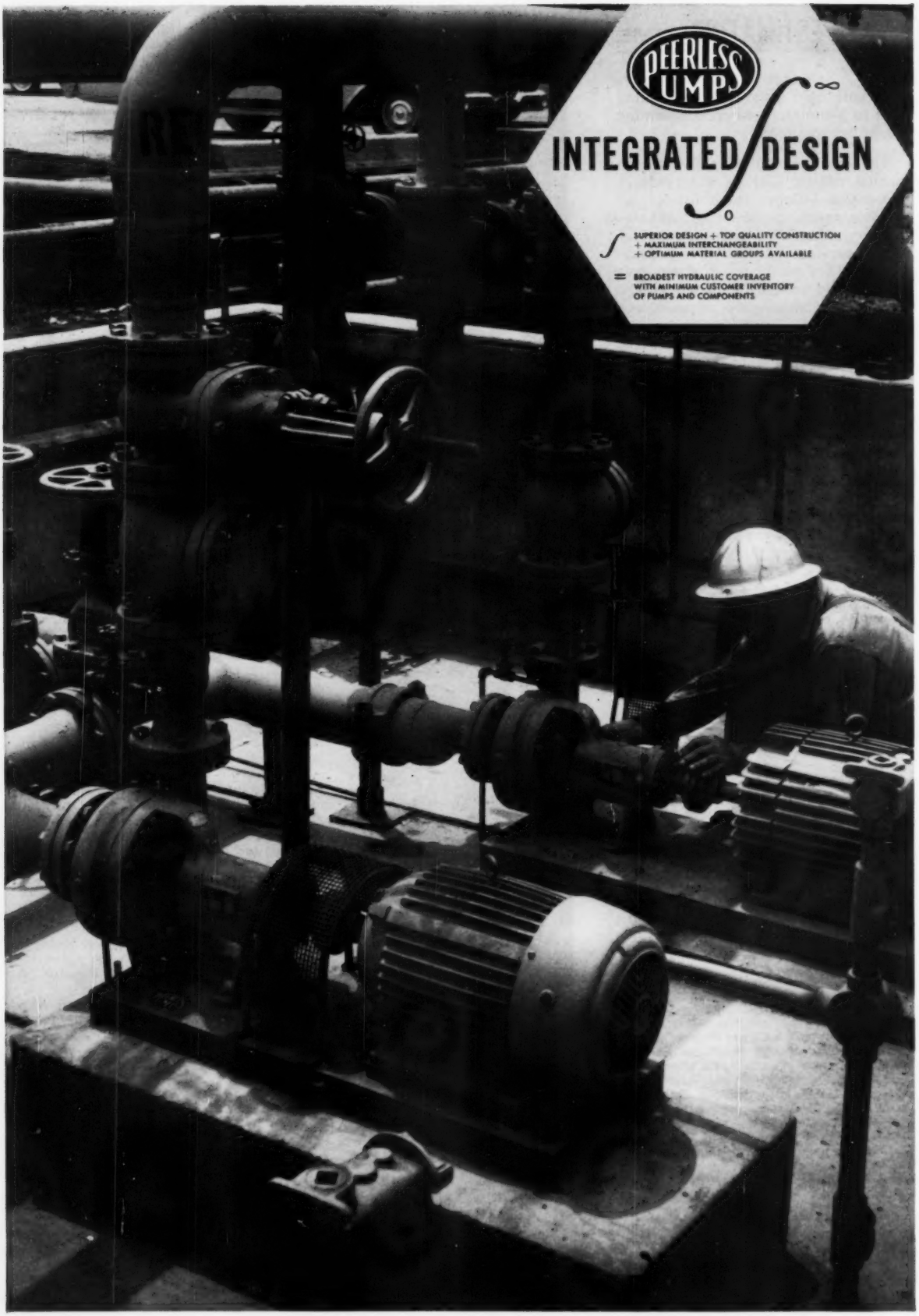
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INTEGRATED DESIGN
SUPERIOR DESIGN + TOP QUALITY CONSTRUCTION
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+ OPTIMUM MATERIAL GROUPS AVAILABLE
= BROADEST HYDRAULIC COVERAGE
WITH MINIMUM CUSTOMER INVENTORY
OF PUMPS AND COMPONENTS

# CAN CUT YOUR PUMP INVENTORY COSTS AS MUCH AS 85%

*Maximum interchangeability means far fewer parts required to fill all your day-to-day needs.*

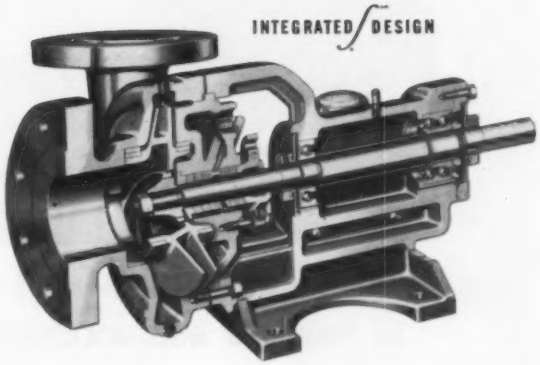
The effectiveness of integrated design of Peerless Type DL and DM process pumps can probably best be shown by a recent customer's order. This customer purchased 150 process pumps for his plant. Of the group, 120 have interchangeable parts. As a result, pump inventory of spare parts can now be cut to a fraction of former requirements freeing important dollars for many other uses. And with the greater interchangeability, the customer predicts even more savings because of speedier maintenance work and less time lost waiting for proper parts.

And, if interchangeability of Peerless Type DL and DM pumps captures your interest, please remember this fact. Because Type DL and DM pumps are of integrated design, you can order them out of stock just the way you need them. For example, there is a choice of semi-open or enclosed impellers; water or air cooled backplates; oil or grease lube bearing housing; packing or mechanical seals; and liquid ends of any machineable metal.

There is one more point to be told about these pumps. They are real performers. Proven time after time, they efficiently pump virtually all liquids used in the process industries.

**INTEGRATED ∫ DESIGN FOR GREATER EFFICIENCY AND SAVINGS**

PEERLESS PUMPS




**VERSATILE IS THE WORD FOR THIS PEERLESS DL—DM PROCESS PUMP**

The Peerless Type DL and Type DM process pumps will handle virtually all liquids used in the chemical, process and refining industries. Both models are single stage, single suction centrifugal types with a vertically split case, and both models have capacities to 1000 gpm, heads to 430 feet and working pressures to 300 psig. Type DL models have a temperature range of 250°F, while the Type DM models have a range of 450°F.

FOR EXAMPLE: WITHIN FIVE DIFFERENT SIZE PUMPS THESE 22 PARTS ARE INTERCHANGEABLE—

1. Shaft
2. Back plate
3. Packing rings
4. Radial bearing
5. Packing gland
6. Thrust bearing
7. Pump frame
8. Impeller lock nut
9. Bearing lock nut
10. Seal lantern packing
11. Key
12. Thrust plate
13. Water slinger & set screw
14. Lockwasher-bearing
15. Gasket-volute case
16. Gasket-thrust plate
17. Oil retainer plate
18. Oiler: constant level
19. Lockwasher-impeller
20. Gland clamp
21. Splash plate
22. Retaining ring bearing

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**Peerless Pump** HYDRODYNAMICS DIVISION

*Offices:*
New York; Detroit; Cleveland; Chicago; Indianapolis; St. Louis; San Francisco; Atlanta; Plainview; Lubbock; Phoenix; Albuquerque; Los Angeles; Fresno.

*Distributors in principal cities.*
Consult your telephone directory.

**Peerless Pump, Hydrodynamics Division, Food Machinery & Chem. Corp.**
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Send me Bulletin B-1608 ☐ Have field engineer contact me ☐
Company_____
Name_____
Address_____
City_____ State_____
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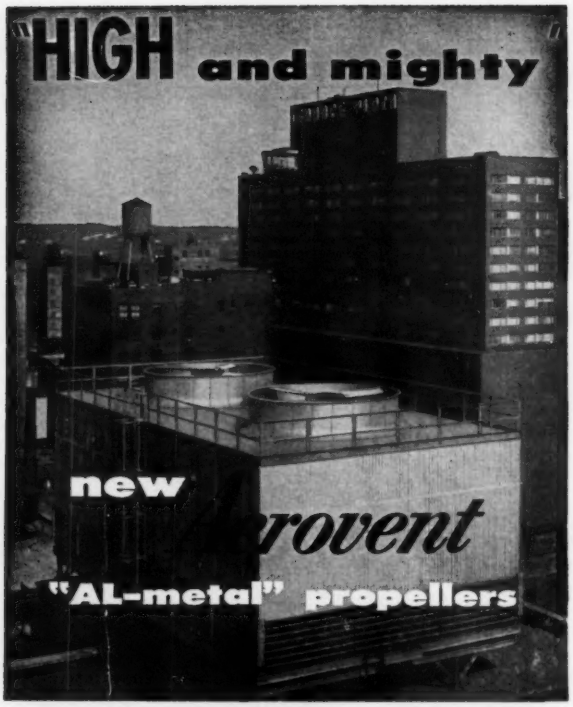
**For more data on advertised products, use Readers' Service Cards, last page.**




## move mountains - of AIR!
### in towers and exchangers

Developed originally for the petroleum industry, Aerovent Large-Diameter "Al-metal" Propellers, constructed of tough, durable aluminum alloy, move great quantities of air at high velocities, in heat exchangers and cooling towers. Pictured above are two 4-blade, 16-ft. propellers in a cooling tower installation. These mighty propellers, with adjustable-pitch "Macheta" Airfoil blades, are job-engineered to individual specifications.

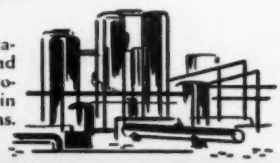
- Sizes 14' to 18'
- 4 or 6 blades

*Write for free Bulletin 510*

**DESIGNED FOR DEPENDABLE OPERATION!**

Endurance tests, conducted at *3 times* normal loading prove the ability of these new large-diameter propellers to withstand severe punishment. Heavy-duty cast steel hubs offer maximum resistance to stresses. Angle settings for each operating requirement, and appropriate alternate settings, assure accurate pitch for any predetermined performance which may be required. 54" to 144" now available in Adjustable Pitch Models.

REFINERIES, pumping stations, industrial plants and commercial buildings use Aerovent "Al-metal" Propellers in major air-moving applications.



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LARGE PROPELLER DIVISION
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TULSA 3, OKLA.
Main Office and Factory
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## *Suppliers . . .*

**CORNING GLASS WORKS** has appointed **William C. Drohan** supervisor of product engineering for its Laboratory Glassware Sales Department. Formerly a product specialist in the department, he will be replaced by **John W. Kopko.**

**JONES & LAUGHLIN STEEL CORP.** has named **Joseph A. Heineman, Jr.,** resident manager of sales, Tulsa office, where he had previously been a salesman. With the company since 1948, he studied metallurgy at the University of Pittsburgh.

**BECKMAN INSTRUMENTS, INC.** has started operation of two new Swiss subsidiaries which will serve as headquarters for foreign sales and manufacturing. They are Beckman Instruments International, S.A., and Beckman Instruments Investment, S. A.

**THE OKONITE CO.** has named **H. L. Ledermann** assistant manager, product advertising. A graduate of Hofstra College with a B.B.A. degree, he has been sales promotion coordinator and assistant advertising manager for two other firms.

**FUEL ECONOMY ENGINEERING CO.,** St. Paul, Minn., has been named manufacturers' representative for Mason-Neilan Co. To handle the complete Mason-Neilan line of products, Fuel Economy will operate in Minnesota, North and South Dakota.

**UNITED GAS CORP.** has established a new manufacturing and marketing division—UGC Instruments Division. The United Gas Research Department has developed a "number of new instruments" to be available through the new division.

**TRACERLAB CO.** has named **Leonard F. Tischler** assistant manager of contract sales. He will be responsible for the procurement and administration of all special contract business for the company's Western Division.

**TELEFLEX, INC.** has appointed two Western representatives—R. J. deRecat & Co., San Francisco, and Ron Marston Co., Seattle, Wash. The two firms will handle most of the Western States.

**PRESSED STEEL TANK CO.** has moved to another location, its district offices serving the New York and Chicago metropolitan areas. The former is at 1199 Main Ave., Clifton, N. J., and the latter at 6634 North Western Ave., Chicago.

**CONSOLIDATED ELECTRODYNAMICS CORP.** has named **Edward G. Canik** wage administrator and **James J. Kennedy** salary administrator. **Harry H. Brown** becomes personnel manager for the company's four central divisions.

**THE CONNECTICUT HARD RUBBER CO.** has completed arrangements to buy the assets of California Rubber Products, Inc., Torrance, Calif. The California firm will be operated as a separate division.



For more data on advertised products, use Readers' Service Cards, last page.

On the fireboat *"City of Portland"*, a Rockwood FOAM system with variable automatic proportioning of the fire smothering foam liquid includes Rockwood turret nozzle convertors, hose nozzles, applicators and extensions. Pumping power supplies a continuous output of 7,000 gpm. Smaller photo shows refueling on this boat with Double Strength FOAM liquid through a trough-like funnel into a 250 gallon FOAM storage tank.

# Rockwood helps protect Portland

**Fireboat's FOAM system provides 3600 cubic feet of fire-smothering blanket — in 3 minutes!**

For up-to-the-minute protection of the harbor area of Maine's metropolis, the fireboat "*City of Portland*" carries a Rockwood FOAM system engineered for fast, effective fire fighting.

This Rockwood balanced pressure proportioning system incorporates all latest mechanical developments, including automatic control of FOAM liquid injection, variable percentage selection, individual selection of FOAM or water discharge and use of nozzles that can discharge FOAM, FogFOAM, WaterFOG or straight water streams.

The FOAM metering valves can be set for Double Strength (3%) or Regular Strength FOAM Liquid (6%). System will maintain the desired percentage automatically, regardless of pressure or flow variations. FOAM tank can be quickly refilled for maximum discharge of 82,000 gallons of expanded FOAM per tankful.

Protective advantages like these are typical of Rockwood systems and products for fire fighting vessels, vehicles or industrial hazards. Tested and Listed By Underwriters' Laboratories, Inc. For details, write to ROCKWOOD SPRINKLER DIVISION, 501 Harlow Street, Worcester 5, Massachusetts.

**ROCKWOOD SPRINKLER DIVISION**

*of The Gamewell Company* • Subsidiary of E. W. Bliss Company

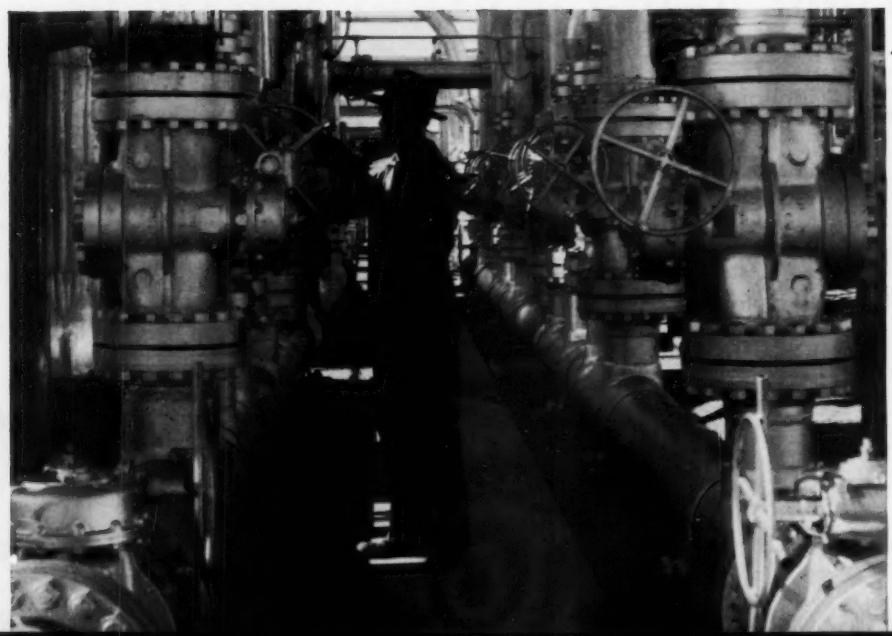
*Engineers Water...to Cut Fire Losses*

*Distributors in all principal cities*



For more data on advertised products, use Readers' Service Cards, last page.

Rolling-in Republic ELECTRUNITE® Heat Exchanger Tubing.
Photo courtesy C. F. Braun & Company, Alhambra, California.



**REPUBLIC ALLOY STEEL STUDS AND HIGH CARBON HEX NUTS** provide the strength needed in high pressure equipment. High tensile strength with tough threads offer maximum holding power and resistance to wear. Tighten smoothly, back-off easily. Send for additional information.

# FARROWTESTED FOR YOU...

## REPUBLIC ELECTRUNITE HEAT EXCHANGER TUBES

Predictable, dependable service is measured for you when you specify FARROWTESTED Republic ELECTRUNITE Heat Exchanger Tubing—in either carbon or stainless steels. And, FARROWTEST is offered as an alternative to other less positive tests at no increase in cost!

FARROWTEST is Republic's exclusive non-destructive eddy-current test that probes for and detects injurious defects so small they pass ordinary internal fluid or gas pressure tests. FARROWTEST looks deep within the tube wall, is calibrated to reject tube with defects as shown in the table, below.

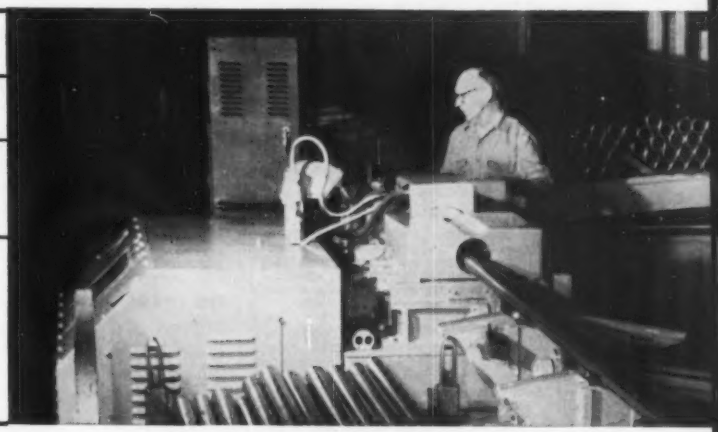
Republic ELECTRUNITE Heat Exchanger Tubing, in carbon steel, is produced to ASTM specification A-214. ELECTRUNITE Stainless Steel Heat Exchanger Tubing is produced to ASTM specification A-249. Both specifications include eddy-current requirements —FARROWTEST.

When ordering new equipment or retubing present units, investigate the advantages and economies of FARROWTESTED Republic ELECTRUNITE Heat Exchanger Tubing. Call your Republic representative, or send the convenient coupon below.

**FARROWTEST REJECT TABLE**

| Wall Thickness (B.W. Gage) | Minor Dimension of Defect (Length or Depth) | Defective Area (Length, Depth Plane) |
|---|---|---|
| 20 | 0.006 IN. | 0.0025 Square Inches |
| 18 | 0.006 IN. | 0.003 Square Inches |
| 16 | 12.5% of Wall | 0.003 Square Inches |
| 14 and 13 | 12.5% of Wall | 0.004 Square Inches |
| 12 and Heavier | 12.5% of Wall | 0.005 Square Inches |

**FARROWTEST** detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.



**FARROWTEST—QUALITY MEASURED FOR YOU.** Not a laboratory theory, not a mere inspection tool, but an exclusive production test that detects and rejects tubing containing defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with the table above, at no extra cost.

**GET SAFE, SURE, DEPENDABLE** shipping with Republic Steel Containers. Full range of barrels, drums, and pails in many styles and sizes up to 55 gallons capacity. Available plain, lacquered, or decorated. Write for a Republic Container Catalog.

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*World's Widest Range of Standard Steels and Steel Products*

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Please send more information on the following products:

- ☐ Republic ELECTRUNITE Heat Exchanger Tubing—Carbon
- ☐ ELECTRUNITE Stainless Steel Heat Exchanger Tubing
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(*"Income Quotient")

# TRAINED SPECIALISTS VITALLY IMPORTANT IN PROCESS ENGINEERING AND ESTIMATING . . .

The rapid, even meteoric development of the petro-chemical industry in the past decade has enhanced the role of importance played by engineering specialists with each step of its progress. Today, the engineer who is equipped with knowledge, study, training and experience in some specific phase of the processing cycle finds himself in an extremely favorable position and nowhere is this more obvious than in the realm of process engineering and estimating.

But industry has a new concept of a "specialist" in the complex of today's business society. He must have a broad concept of the total effort of his company, and cannot be content simply with "doing his job better than anyone else can." Since companies today, large or small, see their profits shrink as costs increase, the engineering specialist must apply his special knowledge or skill to the task at hand with diligence and genius, but with a practiced eye on the effect of his specialty on the profit structure of his company (or his client, or customer, if he is a consultant or supplier).

A generation ago, the "all-round" process engineer was himself a specialist, experimenting, researching, studying developing—combining "educated guessing" with engineering judgment to solve the problems presented. His was the task of dealing with all phases of an engineering process — design, estimating, operating — material and heat balances, temperatures, pressures, flow quantities, the design of special equipment, specification of instruments and controls, stress analysis, corrosion control, etc., etc.

Today, with larger, more complex plants — especially in continuous flow processes — and with greater expense involved in more complicated processes, many specialties have grown from the earlier process engineer specialist, resulting in accelerated advances in each specific field, as demands for more rapid progress are met. The petro-chemical industry in particular has demanded, attracted, developed — and paid for — men of unusual ability and broad vision, expert in their specific fields, communicative, articulate, aware and appreciative of the problems of other specialists as well as of business in general — and therefore more "profitably productive" for their companies. The search for these men increases with each new demand on the industry.

What training, background, experience is needed by today's process engineer to become a specialist? What is required in addition to an extraordinary interest and aptitude for a specific phase of engineering? There are certain technological requirements related to each field, of course, and they are fairly well-defined in each phase, but there are other more general, yet equally important, qualities and attributes on which the aspiring specialist must pass muster.

**Space limitations in this column do not, of course, permit a full treatment of this important subject, but it has been covered more completely and in greater detail in a booklet entitled "Engineering Specialties: A Challenge," and complimentary copies are available to you by writing to: WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and remember, our engineers specialize in designing, estimating and building the heat exchangers in your future.**

## *Suppliers . . .*

Young

Bacon

**THE BRISTOL CO.** has named **Karl Young, Jr.,** and **Henry K. Bacon** full-time instructors in the Education Department. Young has been teaching since 1954, and previously spent several years with Shell Oil Co. He graduated from Yale University. Bacon was formerly with Pennsalt Chemicals Co. He holds an A.B. degree in chemistry from Temple University and has also studied electrical engineering and education.

**HILLS-McCANNA CO.** has named Metal Goods Corp. and Geigher Pipe & Supply Co., both of St. Louis, stock distributors for ball and diaphragm valves. Areas covered will be Houston and St. Louis.

**BETHLEHEM SUPPLY CO.'s** Supply Division has announced the retirement of **T. B. Simpson,** sales representative. He joined International Supply Co., later purchased by Bethlehem, in 1934.

**THE CRANE CO.'s** Swartwout Division has moved production facilities and headquarters from Cleveland to Hooksett, N. H. A new plant for the Hooksett location has been under construction since March 21.

**D. KALTMAN & CO., INC.** has entered into an agreement with Dixon Chemical & Research, Inc., whereby the latter will provide advisory and consulting services, and Kaltman will sell 100,000 shares of stock and warrants to purchase 500,000 shares over a three-year period.

## Test Yourself

(Answer to Quiz on Page 194)

### CASE NO. 1

**Arbitrator Arthur Stark Ruled:** "Current usage would favor the interpretation of the company. We promote a person by elevating him or advancing him to a higher position. It means moving from a lower-paid job to a higher-paid job. A reduction in grade cannot be considered as a 'promotion.' Therefore, Manning has no claim to this job."

## Petroleum Refiner Classified Ads

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**PROCESS ENGINEERS**

**RE-EVALUATE YOUR POSITION**

If you are a graduate chemical engineer with 3 to 10 years experience in one or more of the following: Gas Plants, Gas Plant Design, Gas Treating, Sulphur Plants and General Refinery Process Design.

Furthermore, if you are interested in associating with a company that stresses diversification and you are interested in making a change to the West Coast, Airmail your resume to:

**TECHNICAL PERSONNEL**

**PARSONS**

**617 W. 7th Street**
**Los Angeles 17, Calif.**

**SPECIAL PETROLEUM REPRESENTATIVE**

Established manufacturer of industrial processing materials has opening for two special representatives in the Great Lakes and West Coast areas.

Applicants must be 25-35 years of age, and must have petroleum refinery experience in the mechanical, engineering, processing or operations department. 50% travel, salary, plus expenses.

This is an unusual opportunity for a capable man looking for permanency and above average earnings.

Reply, giving full details of education, experience and personal status to Box No. 338-R.

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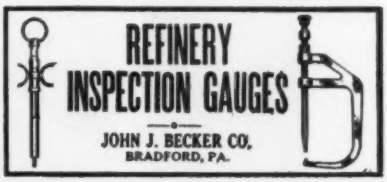

## CASE NO. 2

**Arbitrator Maurice S. Trotta ruled:** "Neither the arbitrator nor the union can or should substitute their judgments for that of the employer on what constitutes 'proper running' of a business, or how many employes are necessary to run an operation. An employer has the financial responsibility for the business, and with this must go the right to operate the business in the manner he believes will result in a successful enterprise. The grievance is denied. The employer has the right to make the decision on the number of employes he requires."

## CASE NO. 3

**Arbitrator Howard W. Wissner ruled:** "The agreement means that during his term of office the shop steward will not be laid off as long as there is work he is capable of performing. Top seniority granted to a steward does not give him a prior claim to overtime assignments in the department just because he is a steward. Joe Grimes was not entitled to priority for the overtime work assignment."

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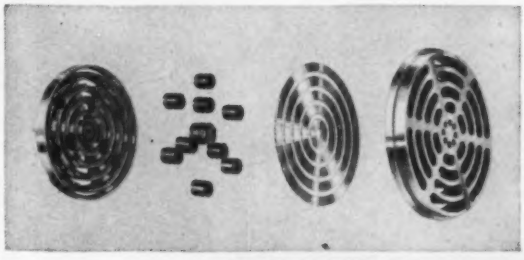

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- lower operating costs

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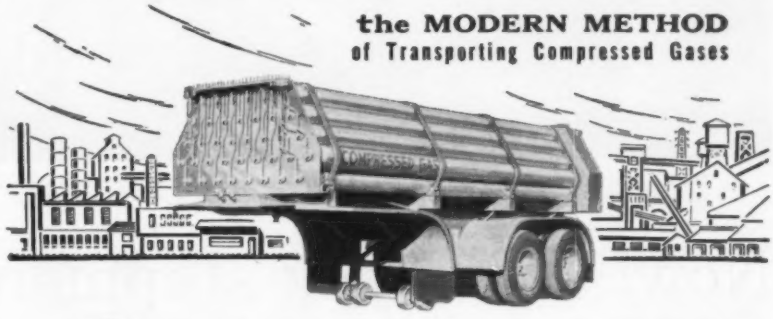
New York 54, N. Y.

the MODERN METHOD of Transporting Compressed Gases



INDEPENDENT ENGINEERING CO.

**gas supply TRAILERS** *tailored just for* **YOU**

- MANIFOLD & CONTROLS — for YOUR Gas and Handling Requirements
- CAPACITY — to meet YOUR Requirements
- SAFETY — Cylinders, Safety Devices, Controls etc., All in accordance with ICC Requirements for YOUR Protection.
- CHASSIS — by leading Chassis Manufacturers with Service Branches throughout the United States for YOUR Convenience.

SEND YOUR INQUIRIES TODAY TO

INDEPENDENT ENGINEERING COMPANY, Inc.
Manufacturers of
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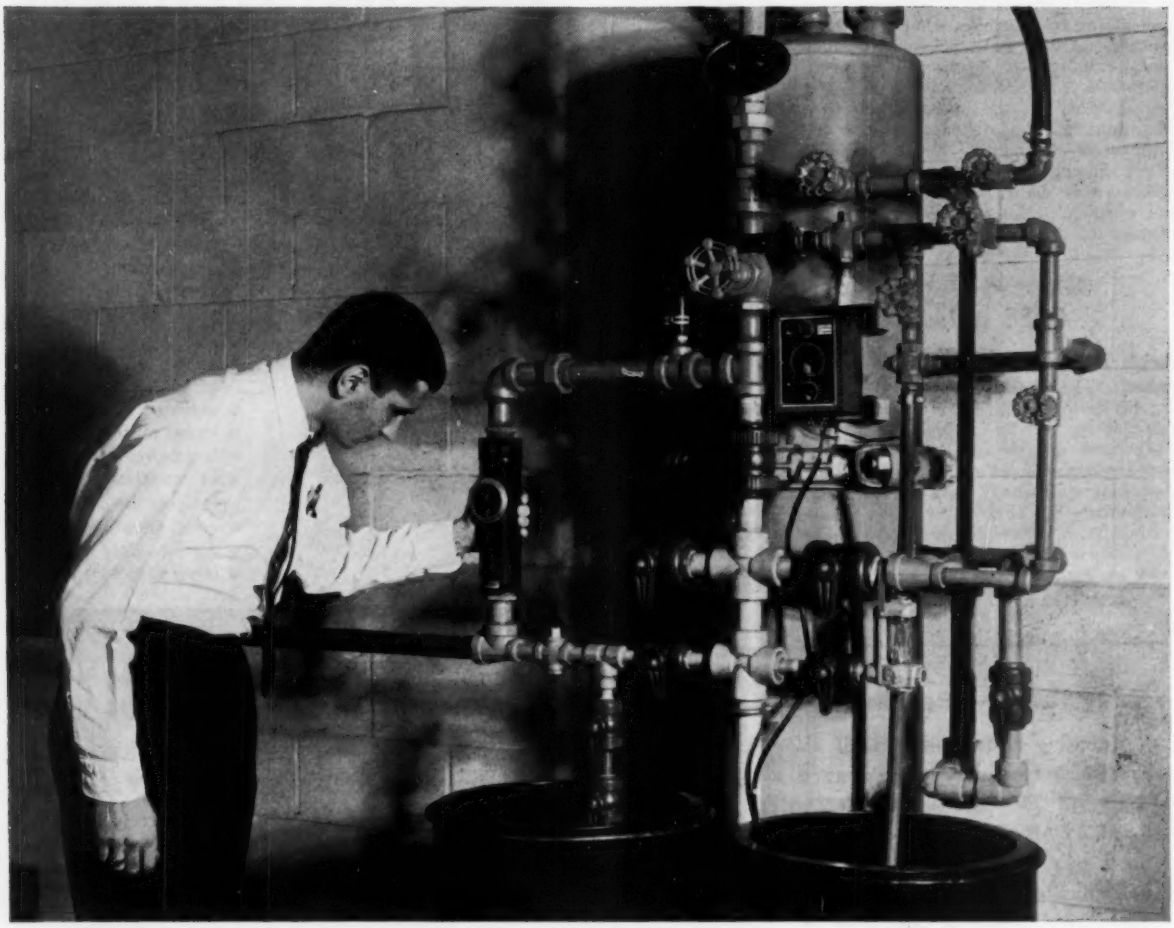
CYLINDERS AND GAS PRODUCING EQUIPMENT
ACETYLENE · OXYGEN · NITROGEN · ARGON
O'FALLON 6, ILLINOIS




For more data on advertised products, use Readers' Service Cards, last page.

# FLUIDICS* AT WORK



MODEL MBD-15A, one of a complete line of "packaged" Permutit ion exchange units, demineralizes 5 to 10 gpm of water to an average conductivity of 0.15 micromhos.

# Now! Two-week shipment available on standard Permutit demineralizers

In 14 days, often less, you can now get shipment of standard Permutit ion exchange equipment to demineralize water for your process or production plant. Here are several models on which you can now get this fast, time- and money-saving service.

**For 5 to 20 gpm . . .**
**"packaged" mixed-bed demineralizers**

These compact skid-mounted, pre-tested units will demineralize 5 to 20 gpm of water to an average conductivity of 0.15 micromhos (approximately 6,000,000 ohms specific resistance per cm or 0.05 ppm total electrolyte content). $CO_2$ will be reduced to 0.1 ppm and $SiO_2$ to about 0.1 ppm. Shipped fully piped, filled with resin, ready to run when you make inlet, outlet and drain connections. Available from stock in four sizes, 12"–15"–20"–24" diameter.

**For 10, 20, 30 gpm . . .**
**three high-volume units**

16", 24" and 30"-diameter single-bed units will demineralize 10, 20 and 30 gpm respectively. Like the skid-mounted mixed-bed demineralizers, construction of these units is of the same heavy-weight materials used for Permutit's custom-designed equipment. This includes rugged PVC plastic interior piping and plastic strainers. Steel shells are lined with $\frac{1}{8}$"-thick PVC plastisol, spark-tested at 10,000 volts. Single-bed units are shipped knocked down, ready for simple and fast field erection and installation.

**For lab, pilot plant . . .**
**MBD-6A mixed-bed demineralizer**

This 6"-diameter unit contains a mixture of Permutit Q cation exchange resin and Permutit S anion exchange resin.

It will demineralize 1 to 2 gpm of water to a low total solids, low $CO_2$ and low silica content.

**How they work, what they include**

We shall be happy to send you full details on the operation of these units, the results you can expect, facts about their construction and installation. Ask for Bulletin No. 4721 or a consultation.

# Glasteel pipe that you can field-cut

Here's a new, rugged, corrosion-resistant Glasteel pipe that you can cut to any length you want with a standard, dry abrasive cutoff wheel.

It's Pfaudler F-C (for "field-cut") pipe.* Once you cut the length you want, you thread, fire-polish and then finish with a belt-sander to provide a flat gasket seat.

Outside, the pipe is steel for strength; inside you have a ⅛-inch-thick glass lining that stands up to all acids (except HF) to 350° F. and to most mild alkalies at moderate temperatures. You can also use this pipe with abrasive fluids, sticky materials, and those you want to protect from contamination.

Pipe is rated at 150 psi and comes in 1½, 2 and 3-inch diameters, in lengths through 10 feet. Stock delivery.

Bulletin No. 989 provides complete specifications.

*Patent applied for

---

# Ion Exchange . . . practical, profitable unit process

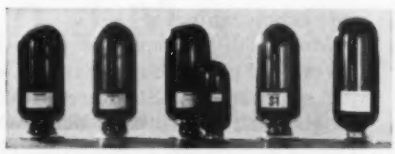
Ion exchange, the Permutit way, is a standard, unit operation for: purification, concentration, separation and addition. A versatile process, it involves many types of dilute solutions.

As the only manufacturers of both resins and equipment, Permutit is best able to control the ion exchange operation from beginning to end.

**Rely on any or all of our services:**

**1. Technical assistance.** Your problem and process will be thoroughly and expertly evaluated in terms of what ion exchange can do.

**2. Wide choice of resins.** From among Permutit's more than 30 ion exchangers, those best suited for your needs will be specified. In this wide selection you'll find many unique and specialized cation and anion exchangers, mixtures and miscellaneous adsorbents.



**OVER 30 ION EXCHANGE RESINS are available from Permutit, along with the know-how and equipment that can help you get the most from this recognized unit operation. Samples on request.**

**3. Dollar-saving equipment.** Frequently the equipment you need is already available as a "package" or can be quickly assembled from standard, stocked components. Naturally, custom units are also part of our service, and automatic equipment was pioneered by Permutit.

If you're interested in ion exchange, either (a) send for a 12-page booklet, "Permutit Ion Exchangers," or (b) send us an outline of your problem.

**NEW FROM PERMUTIT!**

## Complete line— all-purpose Model BD Economy Softeners

Here's an answer to your need for more and more soft water at lower cost.

Taking advantage of new design advancements and standardized mass produced components, new Permutit Model BD Softeners now make Permutit quality available in a complete line, ready for prompt delivery from stock at economy prices.

BD Softeners contain only high-capacity Permutit Q Resin. Absence of subfill eliminates possibility of upsetting bed, makes installation simpler, less expensive. Exclusive double-dish underdrain is shipped completely assembled, further simplifies installation. Standard valve is the famous Permutit Multiport® type.

Available in flow rates of 40, 56, 77 and 100 gpm – with softening capacities of 510, 750, 1020, and 1380 kgr, respectively. Bulletin 4696 gives BD specifications and other details.

## Handy FLUIDICS Buyer's Guide

gives you a complete look at the many products and services you can get through the Fluidics program. It shows you how to get answers to problems in such fields as water and waste treatment, corrosioneering, reaction, metering, fluid control, etc.

For your free copy, write to our Permutit Division, Dept. PR-70, 50 West 44th St., New York 36, N. Y.

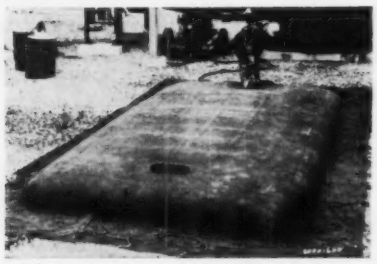
*FLUIDICS is a new Pfaudler Permutit program that provides a modern, imaginative approach for handling and processing liquids and gases more profitably.

**PFAUDLER PERMUTIT INC.**

Specialists in FLUIDICS...the science of fluid processes

# New Equipment & Literature...

## Tank Holds Oil During Transformer Repair

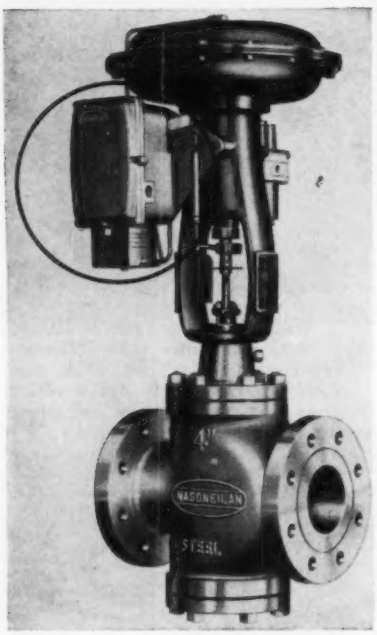


The use of large collapsible tanks made of rubberized fabric in place of steel drums or metal tanks to store oil during periods of repair and routine overhaul, solve the maintenance problem of oil-filled transformers and circuit breakers.

Workmen merely roll out a flat Pillow Tank, pump the oil into it, do the necessary repair work and pump the oil back into the transformer or circuit-breaker. The use of these tanks cuts by almost two-thirds the time previously required to drain and refill the big power units. Goodyear Tire & Rubber Co.

**Circle E1 green card, last page**

## Positioner Has Electric-Pneumatic Control




A new electropneumatic positioner permits combining the advantages of electronic controllers and the power and smooth throttling action of pneumatic control valves. The device is a true positioner, directly comparing valve stem position with controller output signal, achieving dynamic response and positioning accuracy not attainable with any transducer plus pneumatic positioner combination.

The positioner features optimum performance plus simple installation and minimum maintenance. It employs an extra large, stabilized, magnetic force motor to supply high-force changes and a high-capacity air relay, for fast stroking speed. The electrical circuit is adaptable to all presently available electronic controllers.

The relay may be mounted in any of four positions to facilitate piping, and the balanced beam permits installation of the valve in any position without shift in calibration. Stroke adjustment can be made through a plate-covered aperture without exposure of any wiring.

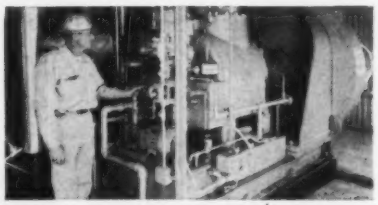
Model 8010 is available for 3-15 psi or 6-30 psi valve-spring ranges, or for split ranging. Standard stroke ranges are from ⅜ to 3 inches and from 2 to 4 inches. Other ranges can be provided. It may be used with either direct or reverse actuators. Mason-Neilan Corp.

**Circle E2 green card, last page**

### Air Compressor For 8,000-bpd Cat Cracker

The first petroleum application for the new "D" style scroll case, single-stage centrifugal compressor is this unit at an 8,000-bpd cat-cracker at Sunray, Texas. The compressor is rated at 47,500 cfm at 12.8 psia and discharges at 17.5 psia.

Capable of higher pressure ratios, greater volume and wider flexibility than previous models, the new style "D" unit is adaptable to the most advanced methods of sealing in industry today. These include the liquid buffered bushing type, ported or unported labyrinth, carbon ring seals, etc.



Another feature of the new design is the pivoted shoe load bearing, newest and most improved bearing design now available in the compressor field. Use of this type of bearing, instead of conventional sleeve bearings, ends oil whirl, reduces oil temperature rise, and eliminates some of the major sources of possible vibration.

Absorbing the thrust load is a double acting Kingsbury-type thrust bearing which is mounted between the two pivoted shoe-load bearings. Installing the thrust bearing in this position reduces over-all length and overhang. This increases critical speeds. Allis-Chalmers Mfg. Co.

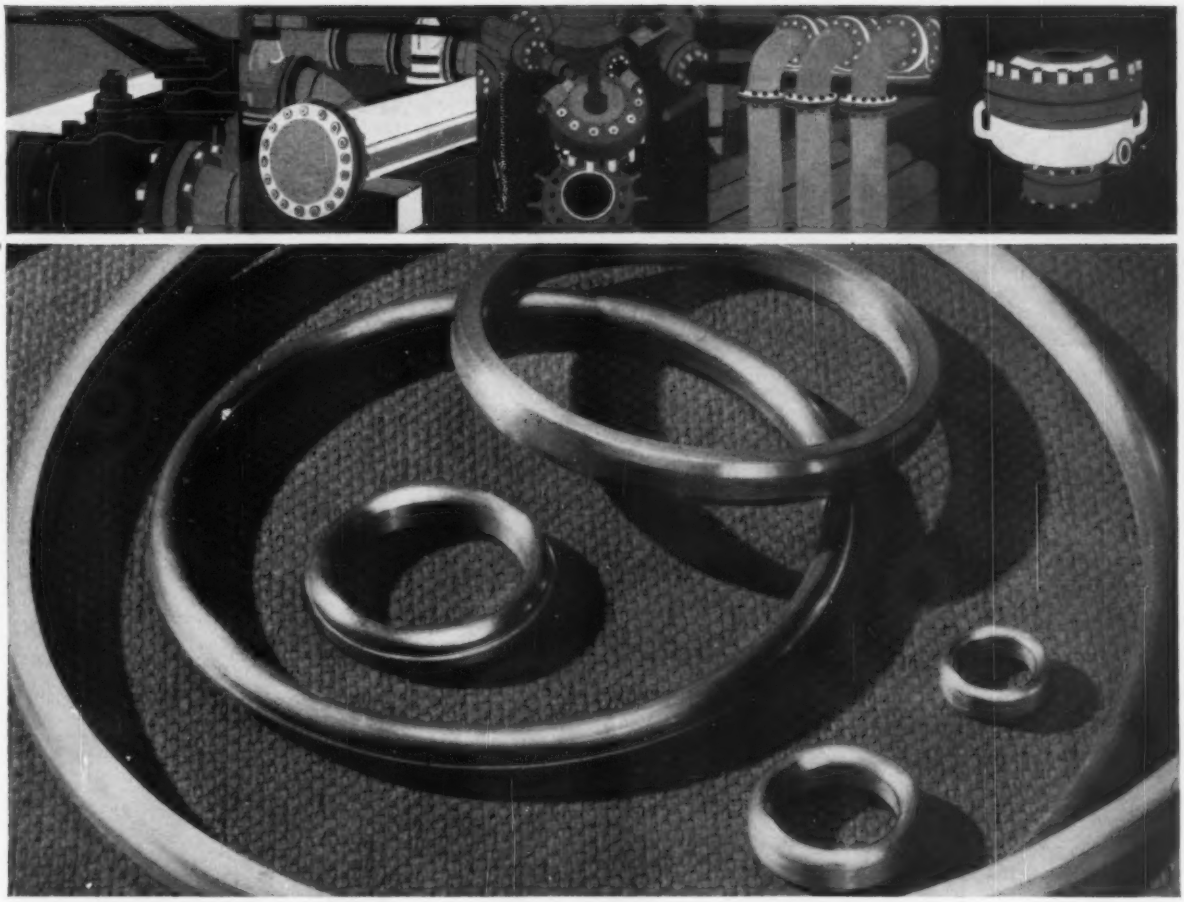
**Circle E3 green card, last page**

### Portable X-Ray Penetrates 1⅞ Inches Steel

The Baltospot 150, a new, lightweight, portable X-ray unit in two model versions features a power range

of 150 KV-3MA and penetration of 1⅞ inch steel.

The unit incorporates a newly designed 360 degree X-ray tube for circumferential radiography—yet is also adaptable to single-beam or directional use by means of an easily adjustable diaphragm. Model 150-D



# Get safer, surer sealing in ring-grooved joints with J-M V-TITE® GASKETS

**YOU WILL BENEFIT BY CHOOSING THE GASKET PROVED IN SO MANY APPLICATIONS!**

If you are concerned with the design or maintenance of ring-type joints, it will pay you to insist on the tighter, more efficient and longer-lasting seal you get with J-M's V-Tite design. Many equipment builders install these outstanding gaskets, and if it's your job to keep this equipment operating at top efficiency, here's a good point to remember: the gaskets that are right to *start* with . . . are right to *stay* with.

V-Tite Gaskets are "right" because every step in their manufacture is meticulously performed. Close tolerances are rigidly maintained for matching of rings with flange grooves. Carefully-controlled annealing keeps gasket hardness well below flange hardness . . . to assure proper flow and sealing without damaging the flange surfaces. Contact surfaces are smoothly finished . . . with no ridges, no tool or chatter marks that cause joint leakage.

J-M produces a wide selection of custom-designed and standard gaskets in any material, dimension or cross-section you require . . . including the new pressure-actuated BX Ring Gasket for extreme pressure service up to 15,000 psi at temperatures up to 250 F.

Complete information from your J-M Distributor. Or write to Johns-Manville, Box 14, New York 16, N.Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE

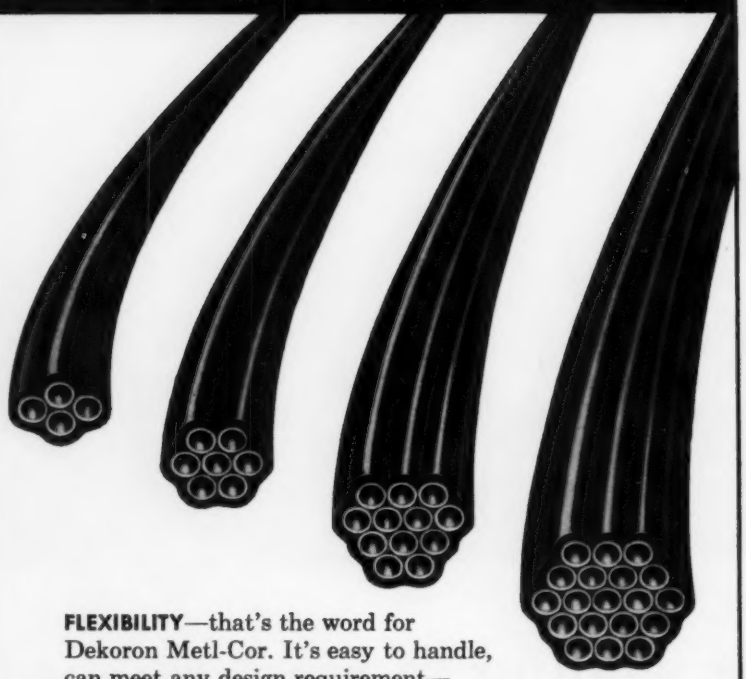
*V-Tite Gaskets meet API specifications*



For more data on advertised products, use Readers' Service Cards, last page.

**DEKORON METL-COR MULTIPLE TUBE HARNESS**

*cuts installation costs*
*bends without distortion*
*solves instrument line corrosion problems*



**FLEXIBILITY**—that's the word for Dekoron Metl-Cor. It's easy to handle, can meet any design requirement—and it's highly corrosion resistant, too.

**FIRST,** Metl-Cor's exclusive Extru-Loc construction makes it easy to bend with no tube distortion.

**SECOND,** the Metl-Cor design is flexible. You can specify Metl-Cor with core tubes in either copper or aluminum . . . in any standard or special OD or wall thickness . . . with almost any number of tubes in each bundle.

**MOST IMPORTANT,** no matter which type or size you specify—you get all the inherent cost-cutting savings and longer life that you pay for.

AA-7511

**Dekoron Tubing is available in many other forms: Dekoron Poly-Cor; M-Ribbon; P-Ribbon; Protecto-Pac; Armored Poly-Cor and Metl-Cor; and single-line Dekoron Tubing.**

*Dekoron® products*
QUALITY · RESEARCH · SERVICE

**SAMUEL MOORE & COMPANY**
DEKORON PRODUCTS DIVISION • MANTUA, OHIO


## *Equipment . . .*

features a wide-angle 60 degree tube which allows up to 50 percent greater linear exposure at any given distance. The port areas on both versions are end positioned for easy access to internal sections too small even to accept the entire head. Forward beam projection materiallly aids in this type of work. Balteau Electric Corp.

**Circle E4 green card, last page**

### Clean-Sweep Redesign Of 4,160-Volt Switchgear

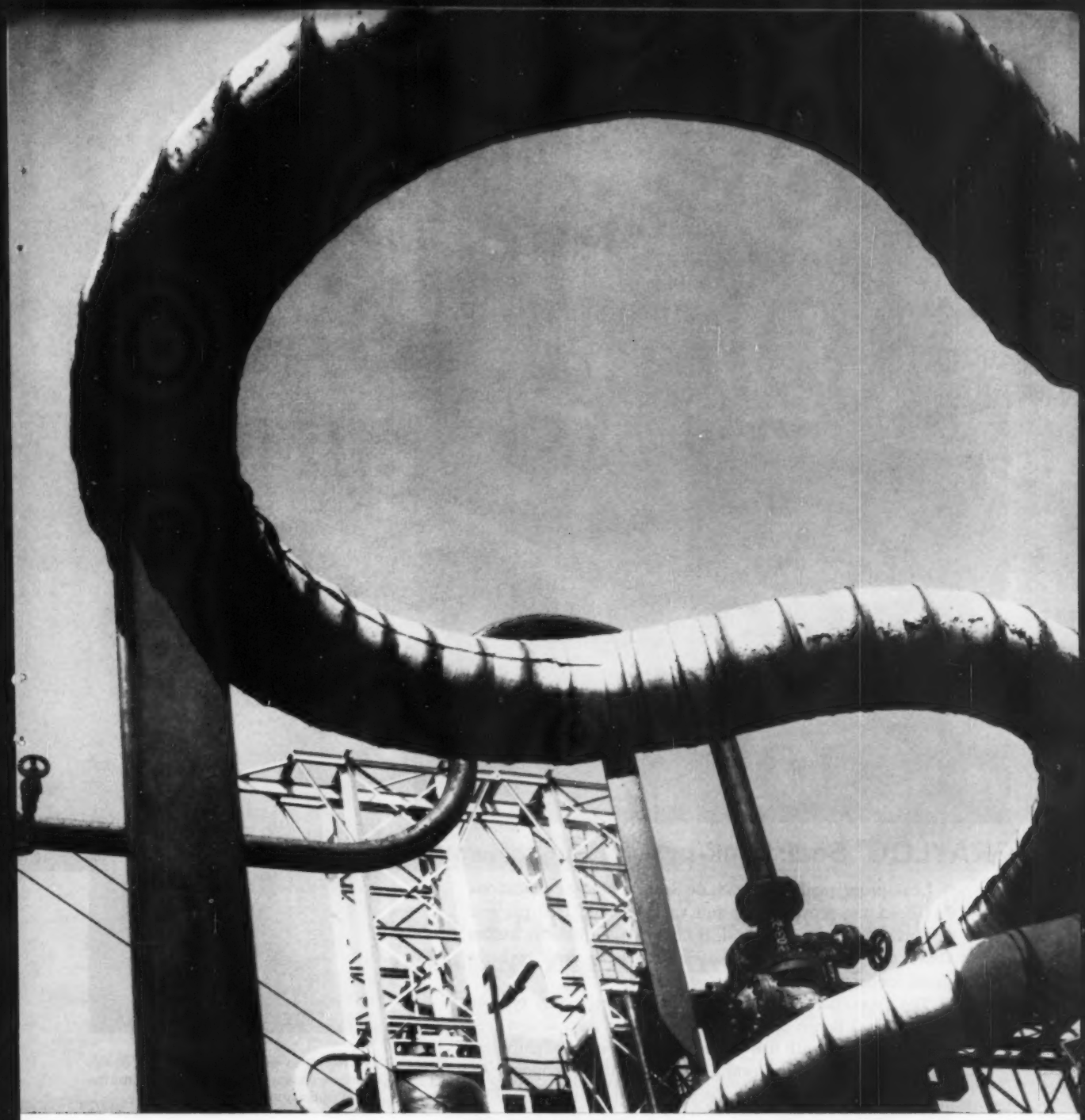
New 4,160-volt circuit breaker and switchgear equipment, incorporating completely new design from the ground up,

has closed-door drawout and indication of breaker position in compartment, stored-energy closing, ironless blowout, faster closing of contacts and faster interruptions of faults, smaller size and floor area, low center of gravity, and enormously increased accessibility from the compartment front for installation ease and maintenance and service. I-T-E Circuit Breaker Co.

**Circle E5 green card, last page**

### Present Scope of Gas Chromatographs Doubled

A Model 500 Linear Programmed High-Temperature Gas Chromatograph, capable of operating to 500° C, nearly doubles the scope of present gas chromatographs. It makes possible for the first



How to get

## AN EXTRA 2000 TO 4000 BARRELS A DAY PER STILL

One eastern refinery increased the capacity of a pipe still from 16,000 barrels a day to between 18 and 20,000 — by modernizing the still in a program that included a Ljungstrom® Air Preheater.

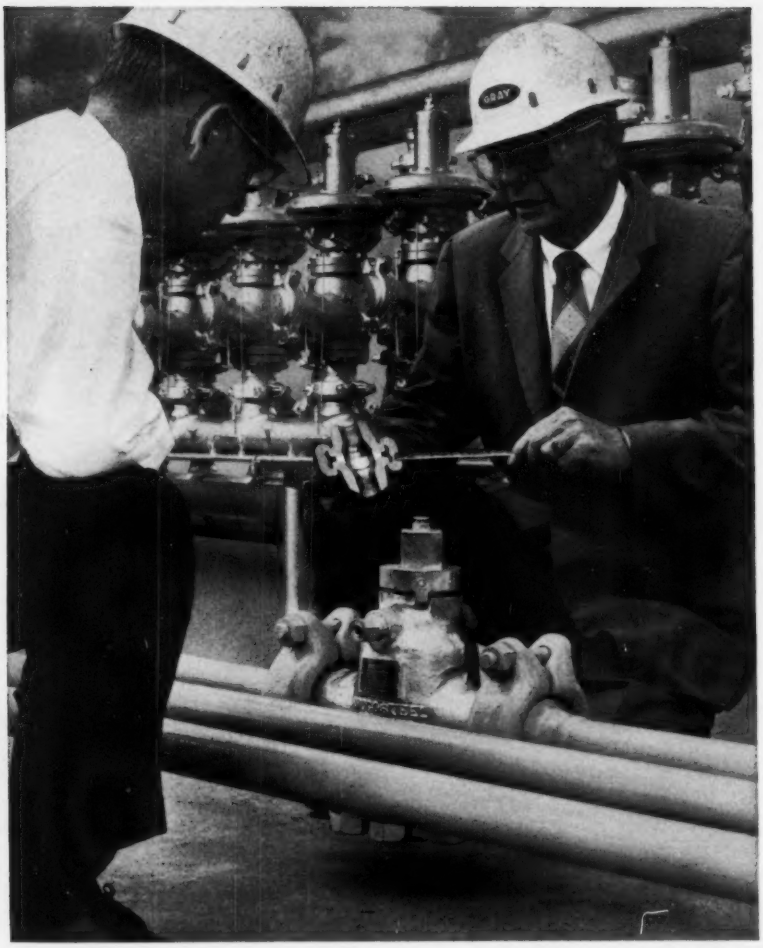
The Ljungstrom boosts throughput like this by recovering waste heat from stack gas and putting it back to work in the combustion chamber. If you modernize to take full advantage of Ljungstrom's heat recovery efficiency, you also get much closer temperature control. At the refinery mentioned above, modern fuel-burning equipment — combined with Ljungstrom — increased product ratings an average of two octane numbers.

The addition of a Ljungstrom Air Preheater can materially increase the capacity of your equipment. Every inch of a Ljungstrom heat exchange surface is as efficient as a foot of tubular heat exchanger.

For more complete details on what the Ljungstrom Air Preheater can do for you, or for a complete analysis of the heat recovery benefits, call or write The Air Preheater Corporation.

**THE AIR PREHEATER CORPORATION**

*60 East 42nd Street, New York 17, N. Y.*



## GRAYLOC® Seal: Leak-proof at any pressure

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

If you want to know more about how GRAYLOC Connections can permanently solve your leakage problems, write for the new GRAYLOC CATALOG on your company letterhead.

GRAYLOC SALES DIVISION

GRAY Tool Company

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## Equipment . . .

time analyses of low, medium and high boiling compounds—from 1 to 75 carbon and possibly even 100 carbon atoms—all in a single run. Typical samples analyzed include crude oil ($C_1$ to $C_{75}$), paraffin waxes ($C_{20}$ to $C_{60}$), fat glycerides, synthetic lubricants, and a host of lower boiling compounds.

A high-temperature tungsten filament detector and the linear programmed temperature technique, i.e., the ability to increase the column temperature during a run in a linearly reproducible manner, makes the analysis of such wide boiling materials possible.

Two types of column heaters are offered: a heater wrapped directly on the column itself, and a fast-heating, fast-cooling air oven whose temperature can be linearly programmed. The air oven arrangement enables the user to make his own columns and use lengths up to 50 feet. F & M Scientific Corp.

**Circle E6 green card, last page**

### Electric Blending System Uses Computer Techniques

A new, completely integrated electronic blending system for gasolines, fuels, and lubes combines the advantages of analog and digital computing and telemetering

techniques to give lowest over-all equipment and installation costs and most reliable operation.

Special features include high-resolution read-out of computed formula; direct blending to transport loading or pipeline; fail-safe control of components with "memory" restores formula to correct value independent of step changes in rate or system pressure; uniformity of blend control and of product increases reliability of sampling and quality control; finished product inventory and tank requirements are minimized—reworking blends and tank turn-overs eliminated; man-hours for operation and supervision are minimized and product standards and profitability can be kept at maximum.

The system can use both positive displacement meters for precise control of stocks and additive independent of vis-

# Jefferson Gas Processing Specialist helps pick the right chemicals

You may be in the initial planning stages of gas processing facilities. Or, you may be altering an existing dehydration or gas sweetening unit. In either event, selection of the right chemicals is most important. Here, Jefferson's Gas Processing Specialist can help.

He will thoroughly review your proposed processes and expected operating conditions with your engineers. In the removal of water by either glycol absorption or injection, the type unit, nature of the gas stream, degree of dew point depression and hydrate inhibition as well as the properties of the glycols are important in determining the *right* glycol . . . ethylene, diethylene and triethylene glycols or HI-DRY® tetraethylene glycol. Similarly in gas sweetening, the type and composition of the gas stream to be treated and final purity of product are important factors in the proper choice between monoethanolamine and diethanolamine sweetening.

Jefferson's Gas Processing Specialist can also suggest the most economical handling and storage practices for your operation, the best shipping means, and, of course, supply all your glycols and amines in the quantity and purity you need . . . Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

Ethylene and Propylene Oxides, Glycols, Dichlorides, Carbonates
SURFONIC® Surface-Active Agents • Ethanolamines • Morpholine
N-Alkyl Morpholines • Polyethylene and Polypropylene Glycols
Piperazine • Piperazine Salts • Nonyl Phenol • Caustic Soda

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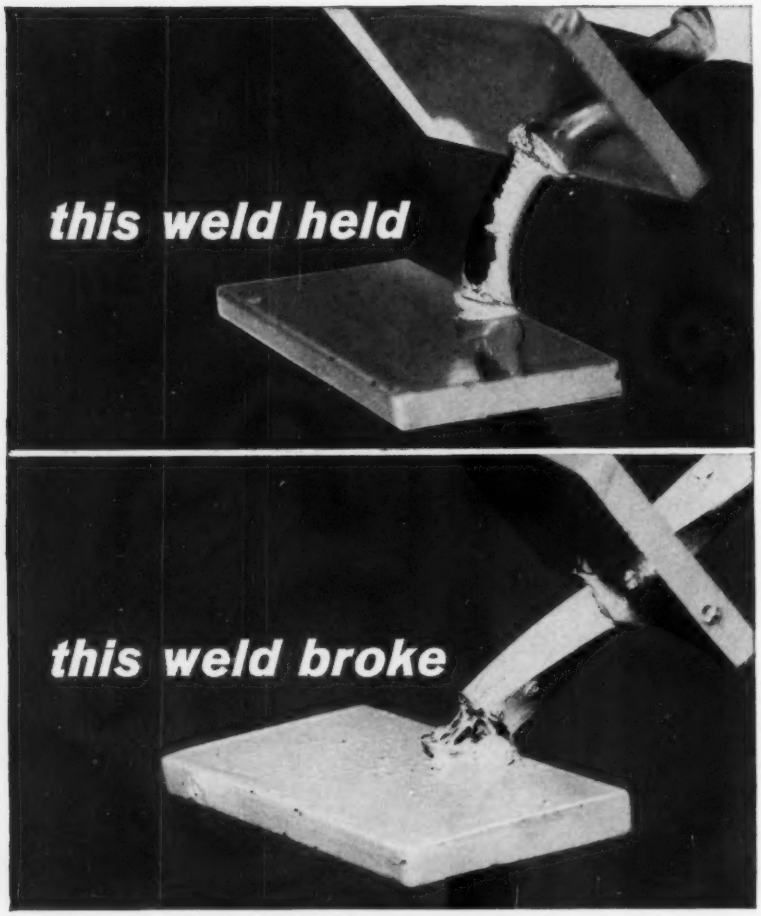
**JEFFERSON CHEMICALS**

061




(Above) This DRAVO TRU-WELD GRATING was deliberately bent, placing far more strain on the welds than there would be in normal service. Not a single weld has parted. This grating will withstand vibration and hard usage.

(Below) **Bent in exactly the same way,** this grating came apart at the welds. The fusion of bearing bar to cross bar achieved by the Dravo method of manufacture prevents this from happening to Tru-Weld Grating.

**the new stronger grating is**

# TRU-WELD

Tru-Weld grating is stronger because it is *made* that way. Its added strength comes from a manufacturing process that completely fuses the metal at cross bar-bearing bar joints and holds the bars to exact spacing. The result is grating that stands up under excessive vibration, heavy traffic or in areas where corrosive fumes and moisture are a problem. And Dravo Tru-Weld grating *costs no more.*

Complete estimating, layout and fabricating services are available. Immediate delivery from stocks maintained at nearby Joseph T. Ryerson Service Centers will help you meet exacting construction schedules.

For more information on this new, stronger grating — call the Dravo representative in your area, or write Dravo Corporation, Pittsburgh 25, Pa.

**DRAVO**
CORPORATION

## *Equipment . . .*

cosity and temperature, or electronic-turbine type meters for large flows of non-viscous liquids. Tetraethyl lead is controlled by continuous electronic loss-in-weight system for maximum range, accuracy and safety.

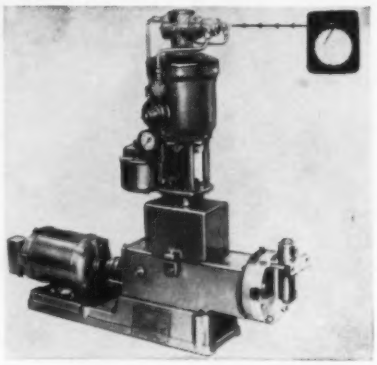
The operator sets up blend formula and production rate by direct readings on plug-in computer modules. A dry-run of 100 barrels or gallons of blend checks computer set-up by direct percentage read-out. Matching monitor modules supervise supply-pump selection, supply pressure, actual flow totals, meter strainer condition and control action of remote equipment. Function is "fail-safe" and can operate unattended—any supply failure or completion of run is signalled by audible alarm. B-I-F Industries, Inc.

**Circle E7 green card, last page**

### Electronics Used To Automate Metering Pumps

Electronic "automation" of chemical metering pumps offers economy through use of electric wires rather than pneumatic tubing.

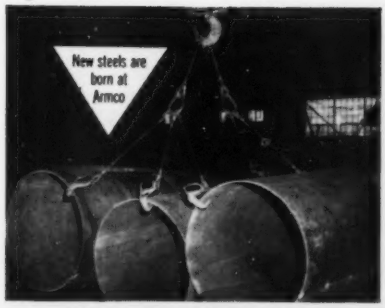
Three different controls offer a combination Electro-Pneumatic which uses air for power only; an All-Electric; and an Electro-Hydraulic.

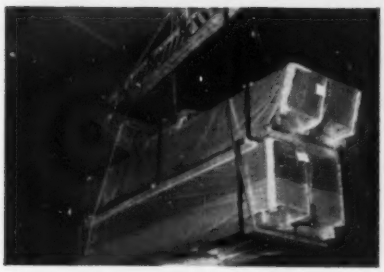


On the Electro-Pneumatic Model (APE), the actuator takes an electronic signal from a controller which in turn pneumatically operates an air cylinder. Supply air used to power the cylinder can be from 30 to 100 psi. The electronic input from the controller can be 0.5 to 5 milliamperes (3,000 ohms), 74 to 144 volts (18,000 ohms) or other ranges as needed.

The All-Electric Actuator Model (AE) is designed to take an electronic signal from either remote manual adjustment of Pulsafeeder output or automatic control from an instrument. The power supply is 110V, 60-cycle, 40-watt maximum consumption. It consists of a gear box, reversible electric motor, slide-wire feedback, and light switches. For manual remote control, a calibrated rheostat allows for convenient resetting of a predetermined Pulsafeeder output. A rheostat control panel and relay are required


For more data on advertised products, use Readers' Service Cards, last page.



# Tuffy has the right answers for every sling need

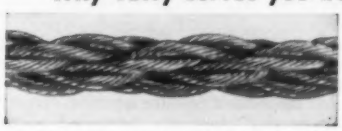
These three shots of Tuffy slings at work just begin to suggest the thousands of different jobs Tuffy does in hundreds of industries.

Tuffy slings, hoist lines and special-purpose wire ropes are tailored to every type use, every weight and shape of load, every set of working conditions.

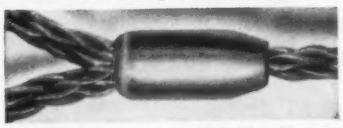
How well do they do the job? Quoting a steel company official: "We are getting double the service life from our 1¼" 9-part machine braided Tuffy slings as we did from 6 x 37 rope type slings."

That's typical of many testimonials that praise Tuffy's combination of better performance, greater safety and longer service life you get from Tuffy products.

### Why Tuffy serves you better and saves you money



**Tuffy's Exclusive Fabric** combines extra strength and extra flexibility to give you ultimate sling construction. It makes knotting and kinking next to impossible. If a kink should occur, it's easily smoothed out, leaving no permanent damage.



**Pressed-On Streamlined Metal Ferrule** gives the tucked eye splice 100% of fabric strength. It's applied under tremendous hydraulic pressure. Streamlining eliminates snags and projections that might injure hands or arms.

### Get in Touch with Your Tuffy Distributor

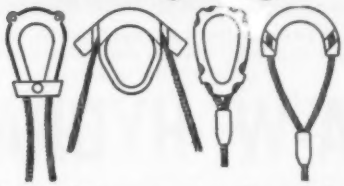
Whether your sling jobs call for machine-braided Tuffy slings or the new line of Union 6- and 8-part hand-braided slings, your Tuffy distributor can supply all your needs. His experience (and the counseling service of Union's branch office or factory staff) are yours to call on at any time. Look up your Tuffy distributor in the Yellow Pages.

## Tuffy® Tips
*—on safe use of*
Slings and Hoist Lines

### How Much Lifting Should Be Done by Muscles?

Individual differences between workers make this a hard question to answer categorically. For a rule of thumb: United States Department of Labor recommends men should handle no more than 50 pounds; women no more than 25 pounds. Of course this is for men and women of average size and height, in normally good physical condition. To remove all doubt, mechanical lifting and hoisting equipment should be used for all loads not comfortably lifted by muscles.

### Use the Right Fittings



Proper fittings can give slings added safety and service life. The sling eye is usually the point of greatest wear in load handling. The proper fitting acts as a shield to take the brunt of this wear. Shown above are some of the standard and advance type fittings. Left to right: (1) *Equalizing Thimble* permits adjustment of the sling leg lengths so irregular loads may be handled on an even keel. (2) *Newco Sling Bridle* will not slip when handling unbalanced loads. (3) *Newco Slip-Thru Thimble* allows passage of an identical thimble through its eye when a regular sling is used as a choker sling. (4) *Newco Slip-On Thimble* eliminates flattening or pulling together of eyes under heavy loads; can be attached or removed in seconds.

**FREE!**
**New Tuffy Sling Handbook**

All about slings from A to Z, including types, dimensions and rated loads. Address **Union Wire Rope Corporation, 2284 Manchester Ave., Kansas City 26, Missouri.** Specialists in high carbon wire, wire rope, braided wire fabric, and stress relieved wire and strand.

4

**UNION** Wire Rope

*Subsidiary of* ARMCO STEEL CORPORATION

OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company
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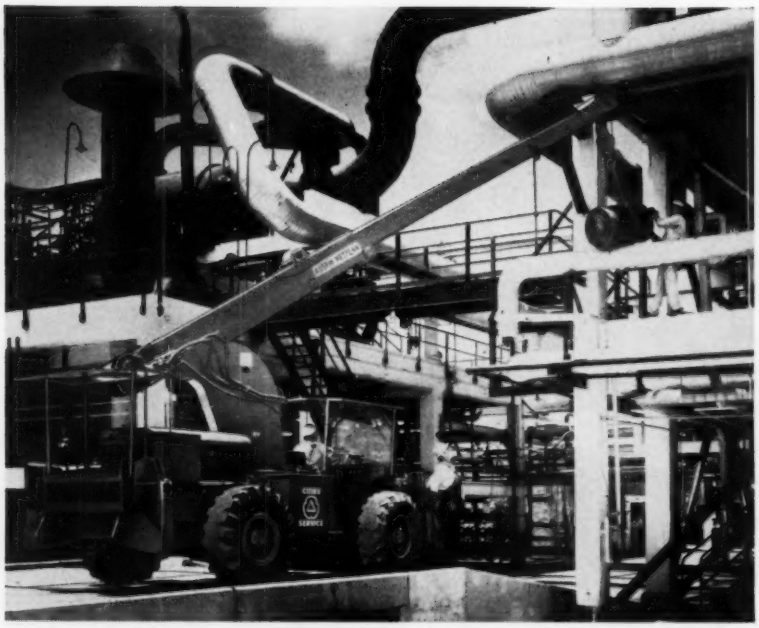


**A-W Hydraulic Model 210 crane** delivers exceptional mobility and 7-ton-capacity range in tight spots which would otherwise require rigging block and tackle.

# A-W HYDRAULIC CRANE REACHES UP AND OVER!

"Our A-W crane works in close quarters to remove and install piping, pumps, motors and valves. It also transports heavy boxes of scrap and other heavy material," says M. E. Dennis, Jr., rigger foreman at Cities Service's Lake Charles, La., refinery.

**Like an extra arm**

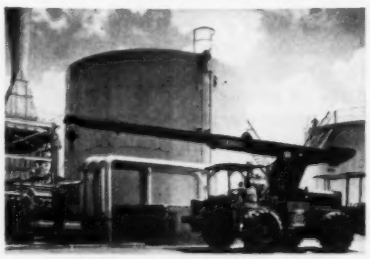
He adds, "Plenty of traction with all-wheel drive, even in muddy terrain. All-wheel steering means added maneuverability in the thousands of confined areas of a refinery. The telescoping hydraulic boom is like an extra arm . . . it reaches up and over, out and in with speed and precision.

"The A-W serves our rigging crew well. It's extremely versatile. It meets Cities Service's exceptionally high safety standards, and that's one reason it's here. Maintenance costs are low. We sure wouldn't want to work without it."

**Best in 40 years**

"Our operator says, 'It's the best machine I've operated in 40 years. I like its maneuverability, pin-point control. It's rugged yet easy to handle'."

Cut your costs with time and labor-saving Austin-Western hydraulic cranes—a complete line of lift, carry and place equipment to speed maintenance, repair and materials handling in refinery operations. Choose from 5 models—capacity ranges from 5 to 11 tons. Ask for a demonstration. Get the facts today from your A-W distributor or write us direct.



**Mobility and maneuverability** of A-W crane make it extremely useful for hundreds of lift, carry or place assignments. Here workmen use it to lower heavy steel plate over pipe trench.

**Austin-Western**

CONSTRUCTION EQUIPMENT DIVISION, AURORA, ILL.

BALDWIN · LIMA · HAMILTON

Power graders • Motor sweepers • Road rollers • Hydraulic cranes


## *Equipment . . .*

in addition to the actuator. For automatic proportional control from an instrument, a slide-wire feedback in 135 ohms or 1,000 ohms can be provided.

Metering pumps fitted with the self-contained Electro-Hydraulic Model (EH) actuator take a low-level DC or AC input signal for positioning and use a standard electric power, single or three-phase, for actuation. This model can be provided in an explosion-proof design. External connections to the actuator comprise two signal wires connected to the power supply. Standard signal range is 4 milliamperes DC. For AC input signals, a rectifier is supplied with the unit. Lapp Insulator Co.

**Circle E8 green card, last page**

### Bellows Expansion Joint Made From 18-8 Stainless

Unlike the conventional method of absorbing pipe movement by expansion loops which are extremely bulky and expensive to install, the Genflex Bellows expansion joint is compact, flexible, and is designed to absorb vibration and movement in all planes, simplifying installation and reducing maintenance.

The standard bellows is produced from 18/8 cold-rolled stainless steel sheet, welded into a tube with a longitudinal butt weld under accurately controlled conditions, the weld being the same material thickness as the adjacent metal. A most important feature of their construction is that they are produced without any circumferential welds. Vokes Genspring Ltd.

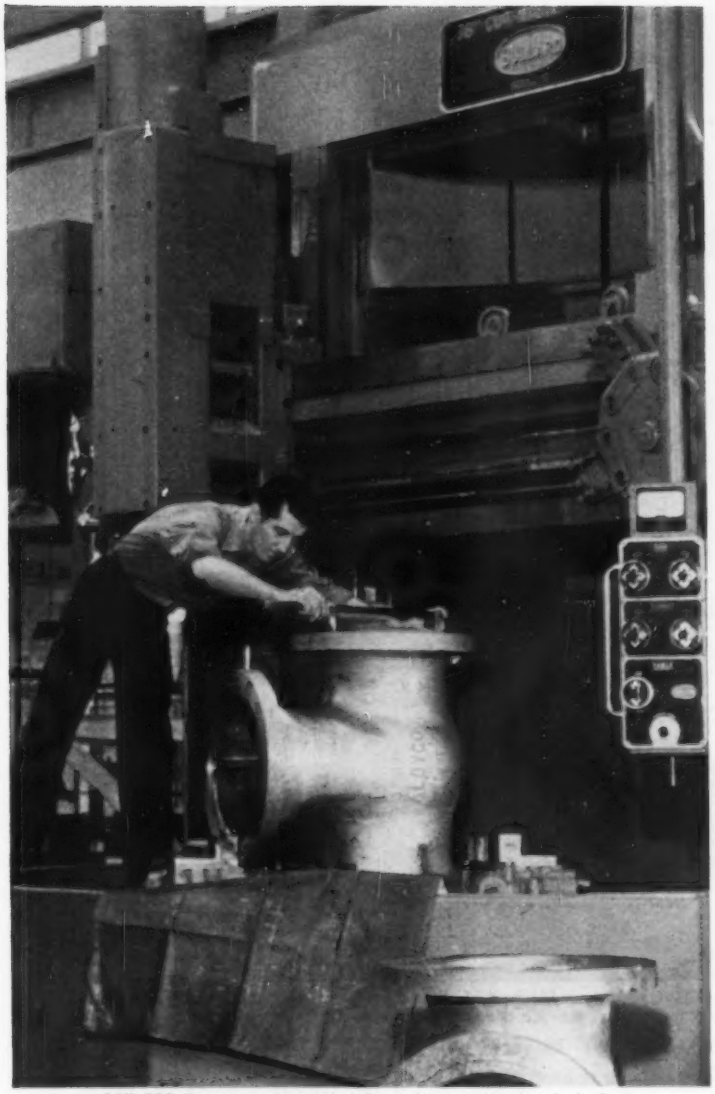
**Circle E9 green card, last page**

### 16-Page Booklet Tells How To Solve Cleaning Problems

Cleaning problems in the chemical industries defy cataloging. There are too many products, too many processes, too much different equipment to be able to say: "This one solution, used this way, will solve all of your cleaning problems." Each problem demands its own diagnosis and its own treatment.

Fortunately, a booklet is available that simplifies the diagnosis and suggests treatments. It's called "Maintenance Cleaning in the Chemical Industry."

The 16-page, illustrated booklet lists soils frequently found on chemical processing equipment surfaces, describes the



**14" 300 lb. gate valve** slated for a large petro-chemical plant, is being worked on one of Aloyco's battery of new Bullards.

# Advanced machines... tools...test facilities expand Aloyco Valves' range of service

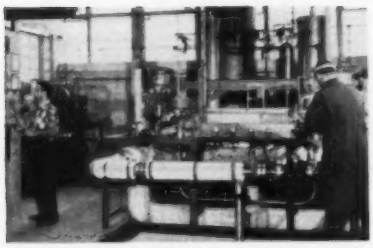
Constant change and improved techniques in modern fluid handling, pose a real challenge for valve manufacturers.

To meet these demands, Aloyco is constantly adding new facilities, some of which are pictured here.

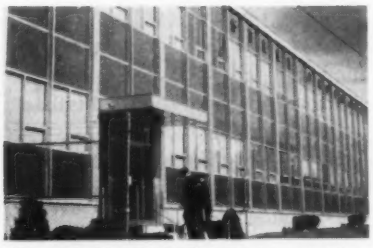
For example, Aloyco Stainless Steel Valves are now available in sizes up to 24", pressures up to 2,500 lbs. at 650°F.

While these new facilities have improved and expanded the quality and usefulness of our entire line, they are particularly important, for example, in the manufacture of valves for the nuclear and missile fields.

For advanced knowledge and ideas plus the equipment to carry them out—take your next valve problem to the specialists: Alloy Steel Products Company, 1303 West Elizabeth Avenue, Linden, New Jersey.



**One of finest hot test loops** in the nation checks out valves at up to 2500 psi, 650°F. Hot tests can spot trouble that would otherwise be revealed only after months of line service.



**New multimillion dollar Aloyco plant** combines new production tools, test facilities, sales, administration, research and development offices and labs into single integrated unit.

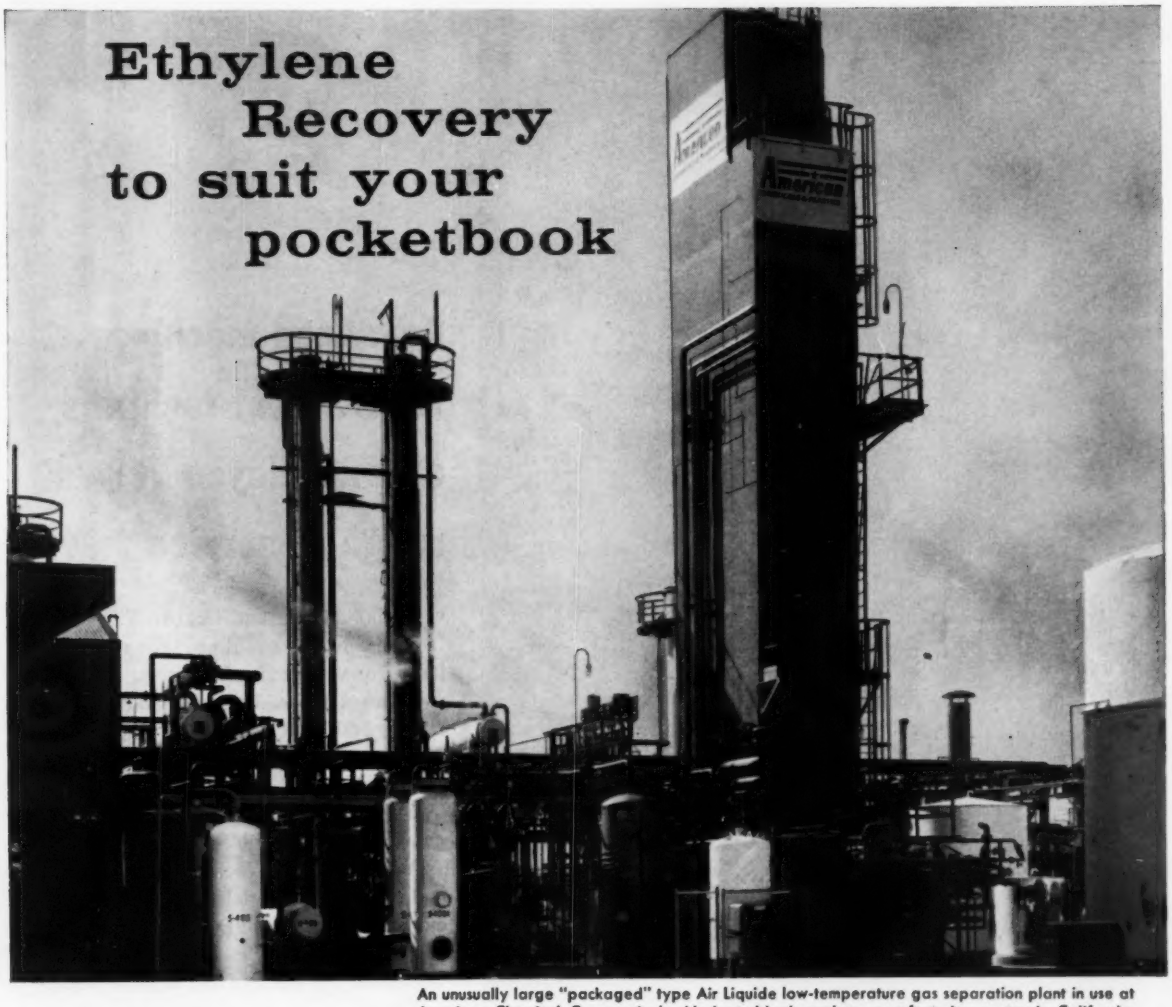
**Boroscope examination** (in pressurized clean room) of specially made nuclear valves follows the application of dye penetrant.

**ALLOY STEEL PRODUCTS COMPANY**

LINDEN, NEW JERSEY

Boston • New York • Wilmington • Atlanta • Birmingham • Baton Rouge • Buffalo
Pittsburgh • Chicago • St. Louis • San Francisco • Los Angeles • Seattle

# Ethylene Recovery to suit your pocketbook



An unusually large "packaged" type Air Liquide low-temperature gas separation plant in use at American Chemical Corporation's chlorinated-hydrocarbon manufacturing centre in California.

Lower capital outlay, elimination of over-production problems, and greater all-round design and operational flexibility. These are some of the positive advantages gained from the use of *low-temperature gas separation* in ethylene recovery.

Low-temperature separation permits the building of smaller units, which result in lower erection and operation costs. Air Liquide designs and builds these smaller units as "pre-packaged" assemblies, with capacities up to 100 tons or more per day.

During the past 30 years, Air Liquide has been recovering ethylene from effluent gases like coke-oven gas (containing 1.5 to 2%) and refinery off-gases (containing 5 to 15%) by the low-temperature process. And Air Liquide has built more ethylene recovery units and hydrocarbon separation plants than anyone in the world.

If you are thinking of ethylene recovery, check first with American Air Liquide.

**In Canada:**
L'Air Liquide,
1210 Sherbrooke St. W.,
Montreal, Quebec.
Telephone Victor 2-5431

**Air Liquide has designed and built the following types of plants, now in use throughout the world:**

• Air Separation — oxygen, nitrogen, etc. • Tonnage Oxygen and Nitrogen (Gas and Liquid) • Rare Gases Recovery • $CO_2$ Purification • Methane Purification • Natural Gas Liquefaction • Coke-Oven Gas Separation • Refinery Gas Separation • Hydrogen Liquefaction • Helium Recovery • Pure CO Production • Heavy Water for Atomic Reactors.

*For complete information write or call*

AMERICAN
**AIR LIQUIDE**
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**Chrysler Building, 405 Lexington, Ave., New York 17, N.Y. Telephone: YUkon 6-6544**

OLDEST IN EXPERIENCE NEWEST IN DESIGN

* **ALL AIR LIQUIDE LOW-TEMPERATURE PLANTS ARE DESIGNED AND BUILT IN NORTH AMERICA FROM AMERICAN MATERIALS, TO NORTH AMERICAN STANDARDS**

solutions and procedures which have been proved efficient in removing the soils under actual field conditions. Case histories show, for instance, how furfural extraction columns, ethylene scrubbers, and heat exchangers have been cleaned by circulating solutions of detergents blended to suit the soils found; and how tank trucks are freed of alkyd resin deposits by pumping solution through a cleaning device introduced through the tank's manhole.

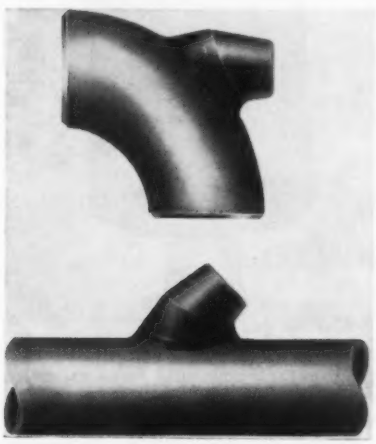
The booklet describes equipment designed to take the work out of cleaning, and methods used to reclaim parts from the scrap pile in a planned salvage operation. Oakite Products, Inc.

**Circle E10 green card, last page**

## Fractionator Reflux Controlled By Computer

Chemical, petroleum and other processors can accurately control cycling fractionator columns despite changing ambient temperatures. The new FRAC (fractionator reflux analog computer) unit maintains a steady-state heat and material balance in fractionators by measuring the internal reflux rate and regulating the external reflux rate accordingly. Minneapolis-Honeywell Regulator Co.

**Circle E11 green card, last page**



## Angle Fitting Provides Improved Flow Conditions

A new angle fitting, the Elbolet, for use in attaching branch outlets at bends in piping systems, can also be used for angled connections to straight lines.

The primary advantage of the fitting design is that it provides substantially improved flow conditions compared with a 90 degree branch intersection made in any manner. The use of angled branch connections for directional flow has been limited in the past by the inability to construct a 45 degree fitting with the

**American 200 Series Chemical Feed Pumps**

**• METERING ACCURACY OF ±1%**

**• CAPACITY TO 1624 GPH.**

New 200 Series Simplex model can pump up to 812 gph. Duplex model has double this capacity. Maximum pressure of 10,000 psi.

Easy, inexpensive operation is assured by these quality features:

- Self-contained lubrication system—no downtime for lubrication.
- E-Z Clean Cartridge Valves simplify maintenance.
- Interchangeable liquid ends for greatest adaptability in the field.
- Precision screw adjustment on crank for easy accurate stroke regulation.
- Sealed Self-aligning bearings on crank and crosshead withstand greater radial and axial thrust loads.
- Crossheads of hardened and ground steel ride on cast iron.
- Heavy duty reducers.
- NEMA frame motors.

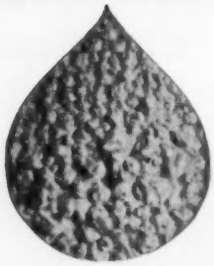
Precision built 200 Series pumps handle a wide variety of "tough," corrosive materials. In Chemical Processing, Refining and Boiler Feed operations, the pumps assure highest accuracy in feeding precisely metered fluids in virtually all ratios, with flow, temperature, pressure, conductivity, PH and other controlled process variables.

Write today for more information.

AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)
pump division
13500 PHILMONT AVE. PHILADELPHIA 16, PA.

# CONCENTROL
## PROVIDES
## LOW COST, EFFECTIVE CONTROL of FOAM and BOILER WATER CARRY-OVER

**PROVED IN THE LAB:**

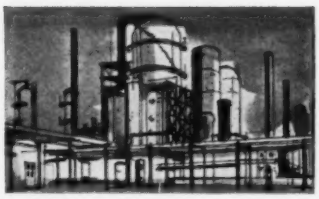


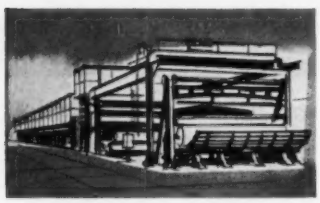
**BEFORE:**
Foaming of highly alkaline solutions in glass test cylinder.

**AFTER:**
Same solution after addition of 12 ppm of Bird-Archer Concentrol antifoam.

**PROVED IN THE FIELD:**

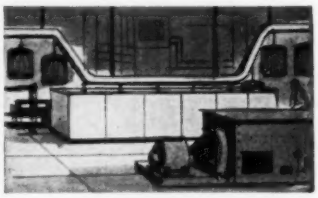
**Concentrol** eliminates foaming, maintains dissolved solids of 10,000 ppm with alkalinity in excess of 2,000 ppm in East Texas refinery.





**Concentrol** reduces blowdown rate from 15% to 5%, keeps steam quality high in paper mill using highly alkaline makeup water.

**Concentrol** eliminates boiler carry-over caused by high alkalinity for an automobile radiator manufacturer using a carbonate water that is Zeolite softened.



**Concentrol** is available in liquid, powder or briquette forms. Fast acting and resistant to hydrolysis or breakdown under normal boiler temperatures and pressures, it can be fed either continuously or in slugs to boilers. Many plants get the advantages of positive foam control *plus* boiler water sludge conditioning by using Concentrol in combination with organic sludge conditioning agents.

**Let a Bird-Archer Water Treatment Engineer prove what Concentrol can do in your plant.**
**Bird-Archer is always as near as your phone.**

BA-802

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**WATER TREATING CONSULTANTS**
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New York, Chicago
The BIRD-ARCHER CO. of California, 415 Brannan St., San Francisco • Offices in Canada and Mexico


## *Equipment . . .*

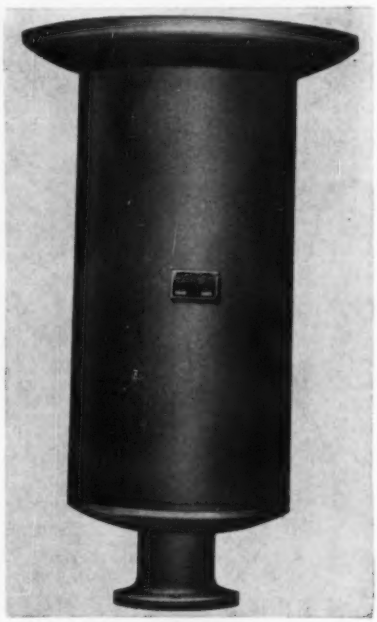
assurance of getting a full penetration weld and a full pipe strength joint.

The combination of angles on both the inside and outside of the Elbolet enable a full penetration weld even in the most acute angle section between the fitting and the run pipe. The varying thicknesses from this acute section around to the obtuse section provides metal placement in the most efficient form with maximum reinforcement at the point of maximum stress. Bonney Forge and Tool Works.

**Circle E12 green card, last page**

### Silencer Quiets Plant Exhaust Noises

The Pulsco Blowdown Mute is an extremely effective silencer for quieting the discharge of steam, gas and air exhausts. Not only are noises muted but the



device serves also to collect and separate condensate, if any, and focus expended energy upward and away from the immediate environment.

Actual test data proves the over-all sound pressure level is reduced to approximately 80.86 decibels at 100 feet.

Capacities range from 1,500 to 500,000 cfm of air, gas, oxygen and hydrogen, and from 3,000 to 1,000,000 lbs/hr of steam condensables. Temperatures from ambient to 1,200° F. Pulsation Controls Corp.

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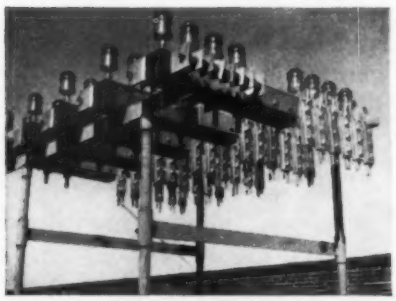
### Cost Data On Impervious Graphite Equipment

A cost data booklet for impervious graphite equipment has been revised to include the latest impervious graphite



In Refinery Atmospheres—*A two-year test conducted in the severe industrial atmosphere of an oil refinery proved the superior corrosion-resistance of Bethalume over competitive coatings. The competitive items lost their protective coatings at an average of 1.15 mils/yr. The Bethalume-coated products lost at an average rate of 0.05 mils/yr.*

At Elevated Temperatures—*Tests, exposing uncoated and aluminum-coated C1020 steel (1000 hours—1200 deg F), showed a 26.3 pct weight loss in the uncoated steel, but no weight loss in the aluminum-coated sample; proving Bethalume-coated studs and nuts well suited for oil refinery high-temperature connections.*

# These test results confirm long service life of Bethalume coating for quenched nuts and alloy studs

The test findings are good, practical reasons why you get more dependable, and longer service life from Bethalume-coated quenched nuts and continuous-thread alloy studs.

***Bethalume coating offers these other advantages—***

1. Double-layer protection consisting of a pure aluminum coating on top of a metallurgically bonded, iron-aluminum alloy.
2. Uniform coating and clean, sharp bolt threads.
3. Prevention of galling.
4. Oil refinery tests proved that aluminum coating withstands hydrogen sulfide better than any competitive coating, especially at high temperatures.

It all adds up to this: the Bethalume coating offers low-cost bolting for your high-temperature installations. The details may be obtained from your nearest Bethlehem office.

Steel

For strength
. . . economy
. . . versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
*Export Distributor: Bethlehem Steel Export Corporation*

**BETHLEHEM STEEL**

BETHLEHEM STEEL



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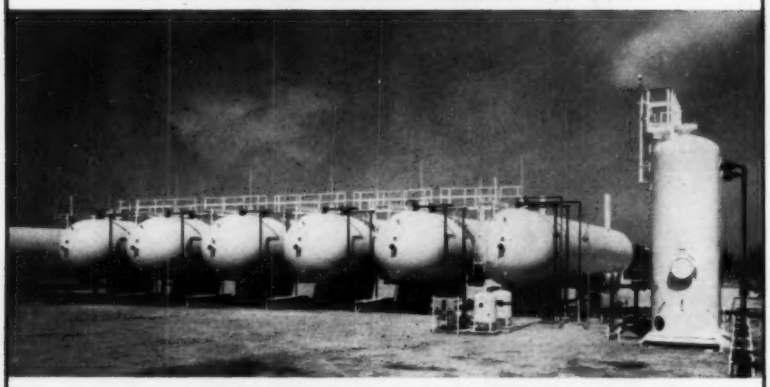
FLINT JOINS WITH ANCO
TO BUILD LARGE
LPG AND $NH_3$ TERMINALS



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Installation—Operation

Complete turnkey construction of LP Gas and $NH_3$ terminals is offered by FLINT and ANCO.

This service can include: Selection of the Site, Designing of all facilities, Fabrication of tanks, Installation of Tanks and other equipment, and Instruction of Your Personnel in terminal operation and management.

FLINT ALSO FABRICATES

- HEAT EXCHANGERS
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A COMPLETE DESIGN AND ENGINEERING SERVICE

*For an economical, worry free terminal project of any size contact Flint or Anco.*

SPECIALISTS IN STEEL FOR INDUSTRY

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STEEL PLATE FABRICATORS ASSOCIATION

## *Equipment . . .*

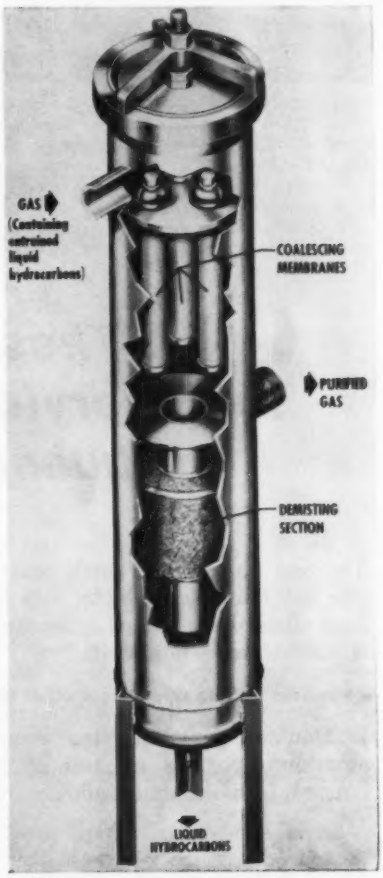
processing equipment, as well as current costs as of December 1959. This booklet contains a typical drawing or illustration of each type of equipment, lists the standard models available, and provides the approximate cost per square foot of heat transfer area for exchangers, or other appropriate cost unit for other types of equipment.

Added to this 3rd printing are "Parallel" and "Modular" exchangers, valves, crucibles, thermowells, and both armored and non-armored types of pipe and fittings. More detailed cost data have been provided for "Cross-Bore" exchangers, immersion heaters, cascade coolers, and rupture disks. Comparative costs and assembly techniques are shown for the two systems of impervious graphite pipe and fittings. Falls Industries, Inc.

**Circle E14 green card, last page**

### Porous Material Removes Entrained Liquids

An efficient system for the removal of entrained hydrocarbons and organic liquids from compressed air and gases is named Coalescer-Demister. The new




product utilizes a system of porous materials. Initially, entrained liquids in the form of small droplets and mist are coa-



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## over multiple source buying of YOUR laboratory needs

**Make Curtin your one reliable source for laboratory supplies. Complete stocks of quality laboratory equipment are maintained for immediate delivery at supply points strategically located in all major refining areas. Technical and Repair Services are readily available all the time to help with your specific problems. Call Curtin on your next laboratory order and get "everything at one source."**

**W. H. CURTIN & CO.**

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Established 1922 U.S.A.

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Sales Offices: TULSA • BIRMINGHAM • CORPUS CHRISTI

Subsidiary: CURTIN DE MEXICO, S.A. de C.V., MEXICO CITY

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.

## MAGNETROL

**AS DEPENDABLE AS MAGNETIC FORCE ITSELF**

● No matter how specialized the liquid level control application, adapting Magnetrol to meet it presents no problem. Whether it's for high pressures, high temperatures, corrosive liquids or any other condition, a few "standard" modifications and the job is done! Operation is so simple no changes in basic design are needed. That's why Magnetrol "fits" practically any application — why "specials" are so often standard with us.

Because of the utter simplicity and dependability of its magnetic principle, Magnetrol has *infinite operating life.* There are no wearing parts to get out of order.

Magnetrols are available for controlling level changes from .0025-in. to 150-ft., with single or multi-stage switching. Our experienced engineering staff is at your service.

**MAGNETROL, Inc.**

**WHY NOT MAIL THE COUPON — NOW**

**MAGNETROL, Inc., 2112 S. Marshall Blvd., Chicago 23, Illinois**

Please send me catalog data and full information on Magnetrol Liquid Level Controls. 7

Name_____

Company_____

Address_____

City_____ Zone_____ State_____



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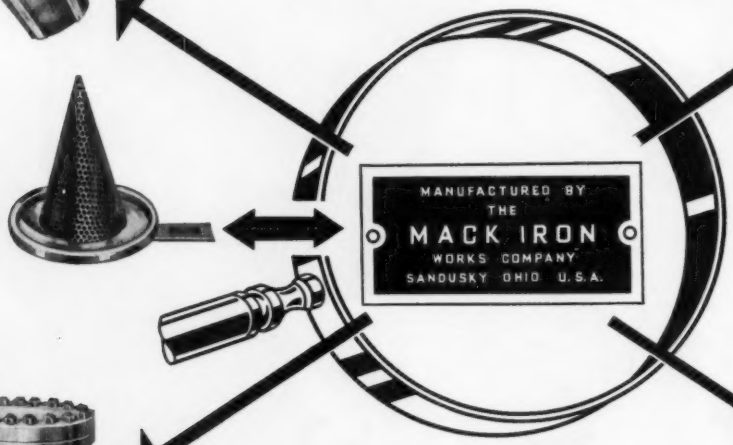
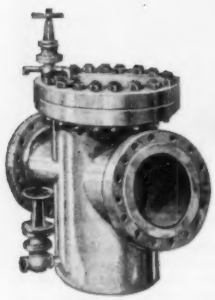
# LITTLE TAG . . . BIG MEANING!

Not a mere name plate, this little metal tag on a piece of equipment is unreserved assurance of quality workmanship and dependability of service . . . *priceless characteristics not solely measured in dollars and cents.*



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# PRECISION PLATINUM THERMOMETERS

*Illustrated Models*

**MODEL 162A** Working standard thermometer. Stability is 0.01 C° over most of range from -182 C° to +260 C° (other models to -265 C° on request). Available on fast delivery.

**MODEL 150B** Miniature liquid hydrogen probe. The diameter is only 0.160 inches.

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**Write for New Catalog No. 115811** for description of 50 different REC probes, including total temperature probes and surface probes.

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**Babbitt** *Adjustable* **SPROCKET RIM**
*with Chain Guide*
**CHANGES THAT DANGER ZONE TO A SAFETY ZONE**

The distance between the floor of your plant and your overhead valves is a DANGER ZONE when piled up boxes or even ladders are used to reach the valves.
Turn it into a SAFETY ZONE — equip your overhead valves with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
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- A hot-galvanized rust proof chain is available for all sizes.

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**Babbitt STEAM SPECIALTY CO.**
**6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.**

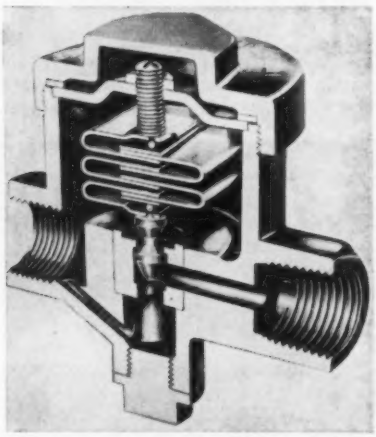
lesced by the new unit into larger sized droplets and are removed from the system. Any droplets remaining in the system are further processed and removed by a specially-designed demisting section.

Units, with capacities up to 7,000 scfm at pressures up to 200 psig, are available. Selas Corp. of America.

**Circle E15 green card, last page**

## Simple Design, Low Cost Thermostatic Steam Trap

A new line of low cost, thermostatic steam traps includes high and low-pressure types in pressure-balanced thermostatic and float-thermostatic designs. They



are unaffected by pressure, water hammer, frost corrosion or rough handling. Operation is maintained by a patented, indestructible, stainless steel, bi-metal thermal element with universal joints. This unique thermal element responds only to temperature and has proved more reliable than bellows and diaphragm types of steam traps which are subject to failure.

Maximum resistance to corrosion and metal fatigue is accomplished by use of forged aluminum-bronze for the bodies and stainless steel for all working parts. Simple design and precise manufacturing control assure "minimum steam loss and trouble-free operation" in a wide range of applications including superheat service to 500 F.

Pressure ranges for thermostatic steam traps are vacuum to 25 psi, vacuum to 65 psi, vacuum to 125 psi, 0 to 225 psi, 0 to 300 psi. Pressure ranges for float-thermostatic types are 0 to 75 psi and 0 to 150 psi. MIL Div. Farris Engineering Corp.

**Circle E16 green card, last page**

## Antioxidant Effectiveness Covered In Brochure

The applications of Tenamene 3 (2,6-di-tert-butyl-p-cresol) as an industrial

True balanced vapor-pressure! That's why NICHOLSON STEAM TRAPS increase Thermal Efficiency . . . and Here's How!

When live steam contacts the bellows of a Nicholson Trap, the pressure inside the bellows equals the pressure outside. With both pressures balanced, the spring action of the bellows closes the trap. When condensate collects around the bellows, pressure inside drops causing outside pressure to compress the bellows and open the trap.

Briefly, this is true balanced pressure and is the operating principle of Nicholson Thermostatic Steam Traps. That's why they discharge condensate and air quickly, positively and intermittently . . . and why they help you get full thermal value from every pound of steam and full productive value from your steam equipment. They provide greater capacity, too . . . up to six times that of ordinary traps. And there's no steam waste either, because seats and valves are of hardened stainless steel, finely ground and accurately lapped for sure, tight shut-off.

As for maintenance, it's practically nil . . . and here's why. In this simply designed trap there is only one moving part. No links, pins, pivots or levers to go wrong. No adjustable orifices to stick, wear or become clogged. No need for valve and seat changing. In short, no downtime because of trap failure.

Naturally, plus efficiency like this does not come at "bargain" prices. You can get cheap traps, of course. But remember this: *price* only shows up on the dealer's shelf; *value* is what shows up on your lines . . . and with Nicholson Traps it shows up in discharge action you can rely on to keep temperatures high and even for full thermal efficiency at point of steam use . . . efficiency that can often increase production as much as 20%.

This is low trap cost, where it really counts. Let's tell you more.

**W. H. NICHOLSON and COMPANY**
**12 Oregon St., Wilkes-Barre, Pa.**
***Offices in principal cities***

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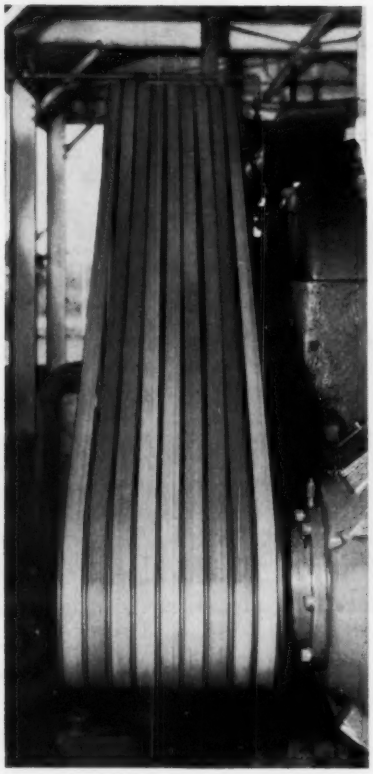
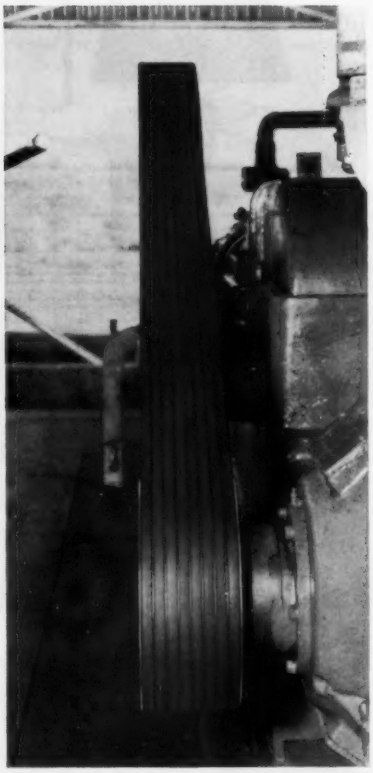
# SAME JOB Fewer Belts . . . Narrower Sheaves Less Bearing Load . . . Lower Costs



Conventional V-Belt Drive



Thermoid-Quaker "Powerflex Wedge" V-belt drive

## Quaker Thermoid "POWERFLEX WEDGE" V-BELTS SAVED $402 ON THIS JOB

The shape of new "Powerflex Wedge" V-belts is narrower with added depth . . . for a big jump in "pulling" power. More pull means fewer belts, smaller sheaves, shorter centers and less bearing load; *more efficient power transmission.* Costs on this documented "Powerflex Wedge" installation amounted to a savings of $402.14 over the conventional V-belt drive.

But design isn't the whole story! New Thermoid-Quaker rubber compounds and tougher, load-carrying cords play a vital role in prolonging belt wear . . . for even greater savings.

Check "Powerflex Wedge" V-belts for better power transmission. Your Thermoid Division Distributor is there to serve you. *Thermoid Division, H. K. Porter Company, Inc., 200 Whitehead Road, Trenton 6, N.J.*

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**PORTER SERVES INDUSTRY** with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.


## *Equipment . . .*

antioxidant are discussed in a new 16-page brochure.

Performance charts and graphs illustrate the effectiveness of Tenamene 3 as an antioxidant for such materials as lubricating oils, turbine oil, paraffin wax, motor and aviation gasolines, rubber, paints, elastomers, polyethylene, and insecticides. Other miscellaneous industrial applications are described and complete data on the physical properties of Tenamene 3 are presented in tabular form. Eastman Chemical Products, Inc.

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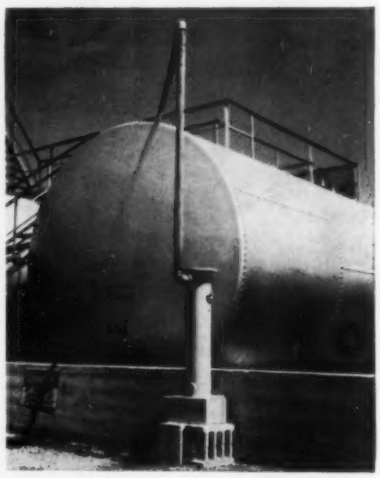
### Drier Takes Moisture Out Of Tank Venting Air

By installing a new drier in the vent piping, condensation of water vapor within a tank can be prevented. When the moisture-sensitive liquid in storage



is removed, the air replacing the liquid is completely dried by the desiccant column in the vent line. Breathing through the vent line occurs daily from changes in atmospheric temperature and pressure.

The Drierite unit is designed to protect tanks from 500 to 50,000 gallons depending upon climatic conditions, and produce bone-dry air for evacuation flow rates up to 150 gallons per minute. The pressure drop does not exceed 2 inches of water at this flow rate.

The cylindrical drying tower is constructed of steel and can be based on a cat-walk, or other accessible location and then connected to the tank vent line. Over-all height is 40 inches; diameter 8 inches. Inlet and outlet connections are 2-inch pipe. Water vapor capacity is 5 pounds—desiccant capacity 50 pounds. W. A. Hammond Drierite Co.

**Circle E18 green card, last page**

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without this?
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Spray Nozzles
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# STOP WEEDS YEAR 'ROUND

## with UROX® Weed Killer

***Just one application controls weeds and brush for 8 to 18 months!***

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**Longer lasting! Economical!** One application gives you 8 to 18 months control. And effects are cumulative. Light "booster" doses extend control from year to year.

**Available in 2 easy-to-use forms!** *Liquid* UROX Weed Killer is ideal for spraying large overgrown areas. Won't clog spray nozzles or strainers. Does not precipitate out in the tank. Stays in solution perfectly. *Granular* UROX is the convenient, inexpensive way to treat small weed-infested areas. Can be applied quickly and easily with any mechanical or hand-operated spreader.

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Weed Killer Dept. PR 70
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|---|---|---|---|---|---|---|---|---|---|
| | WET METERS | | | | DRY METERS | | | | |
| | A | B | E40 | P13 | D1 | D4 | CD1 | CD4 | 218 |
| Cu ft/rev | 1/50 | 1/50 | 1/10 | — | 2 | 2 | — | — | — |
| Cu ft/hr | 20 | 10 | 40 | — | 200 | 400 | — | — | 190 |
| l/rev | ½ | ½ | 2½ | ½ | 50 | 50 | 10 | 10 | — |
| l/hr | 500 | 250 | 1,000 | 250 | 5,000 | 10,000 | 6,000 | 11,000 | 5,400 |

*Maximum pressure is 10 in. W.G. (254 mm W.G.) except for Type 218 for which it is 5 p.s.i. (0.35 kg. cm²)*

**TYPE 'E40' HEAVY DUTY TEST METER**
Calibrated in litres or cubic feet. Capacity 1,000 litres or 40 cubic feet per hour.
This meter is designed for heavy use in oil refineries, chemical works and similar industries. Despite its large hourly capacity the 'E40' test meter is accurate to plus or minus 0.25% over the entire flow range. It is made of stainless steel and is well suited for many corrosive gases. With its removable back, the meter is easily dismantled for cleaning. Ask for leaflet T/47 for details of the full range of Test Meters.

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For more data on advertised products, use Readers' Service Cards, last page.

# How General Electric PRODUCT INNOVATION

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Quality control influences every G.E. operation, from order receipt to shipment.

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Product research and development is advanced in all 98 G.E. laboratories.

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Customer-oriented application engineers assist you with systems integration.

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The latest tools of process analysis are available for studies of your problems.

### INSTALLATION AND SERVICE ENGINEERING

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### SYSTEM CO-ORDINATION

G.E.'s systems experience focuses the full Company capabilities on your order.

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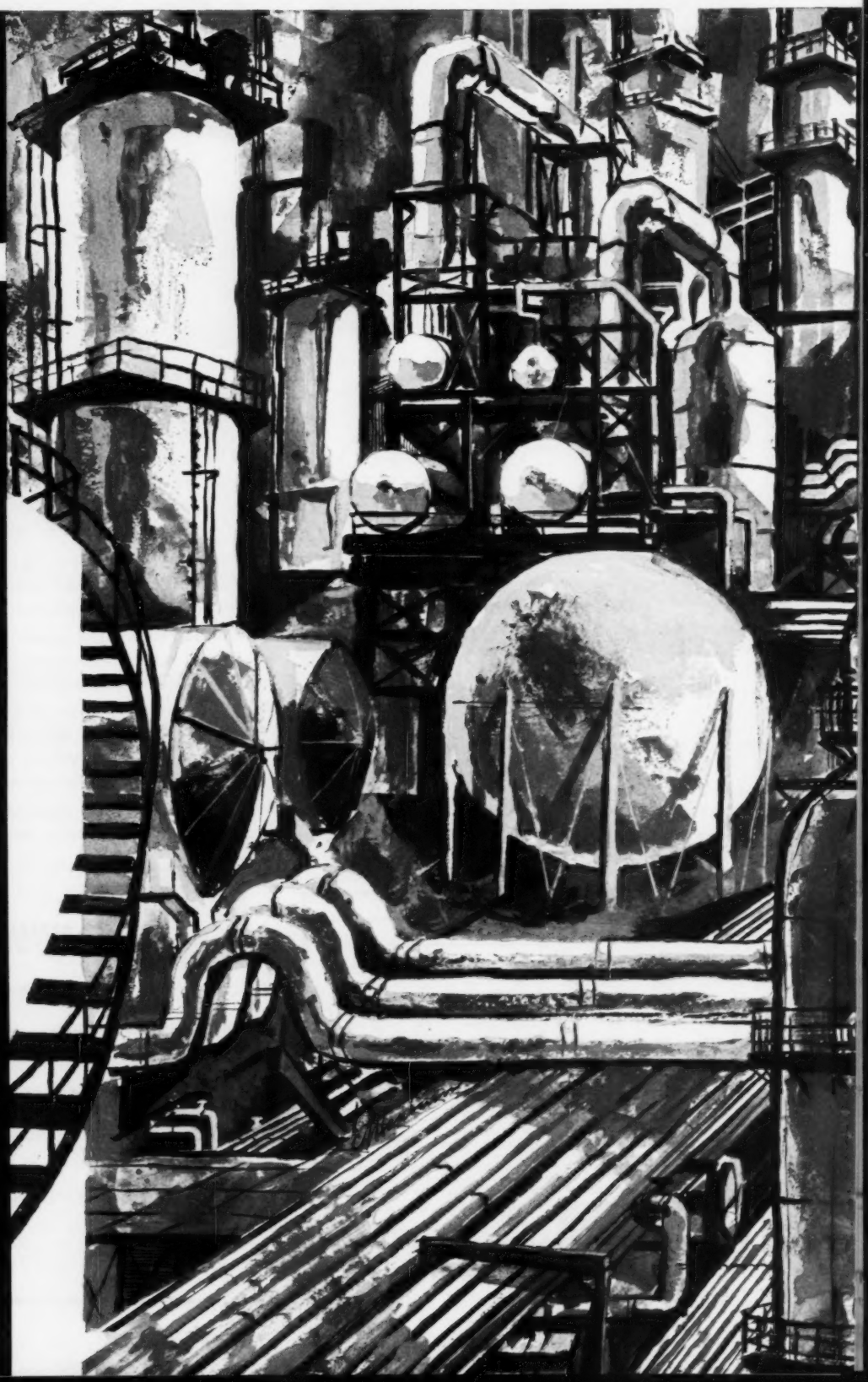
More than 50 G.E. Service Shops offer you 'round-the-clock maintenance service.

### PROMPT DELIVERY

Accurate delivery cycles put your new G.E. equipment to work for you—on time.

### VALUE ANALYSIS

Value Analysis gives you optimum combination of product value and economy.



*helps give the petroleum and chemical industries*

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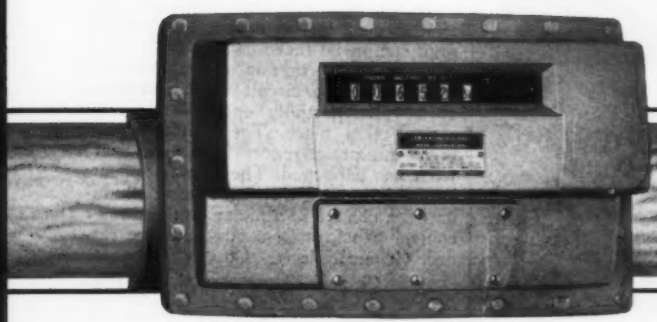
Recognizing your urgent needs for flexibility to meet fast-changing process requirements, General Electric is constantly developing more *versatile* products. General Electric investment in research and development, currently more than three times as much per sales dollar as the average for all industry, keeps G-E product versatility in step with your process requirements.

**AN EXAMPLE OF GENERAL ELECTRIC PRODUCT INNOVATION** is the new gyro-integrating true mass flowmeter. This versatile instrument continuously, accurately, and directly measures, *in pounds*, fluid streams over wide fluctuations in flow rate, density, pressure, temperature, and viscosity. The mass flowmeter eliminates the time-consuming—and sometimes erroneous—conversion of volume to weight. And *one* basic meter accurately measures a great number of industrial liquids and gases.

**FOR MORE INFORMATION** on G.E. product innovations that give your processes additional flexibility, call your local General Electric Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y. 651-01

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**



**NEW GENERAL ELECTRIC** true mass flowmeter handles many different process measurements:

**LIQUEFIED GASES • INDUSTRIAL LIQUIDS**

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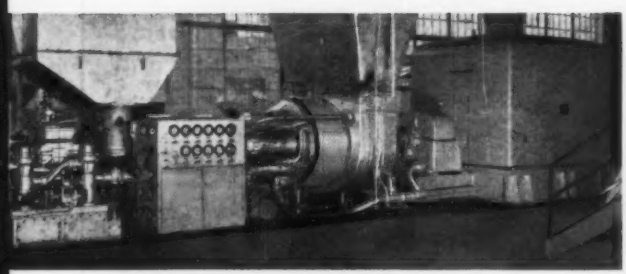
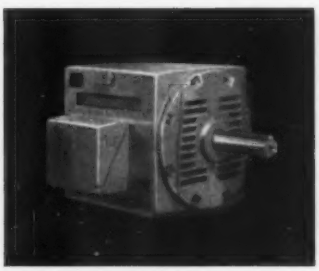


**INDUSTRIAL GAS TURBINES,** pioneered by General Electric in 1948, are continually being improved for simultaneous double duty: reliable shaft power and economical heat for process hot air or steam.



**NEW CUSTOM '8000'*** a-c motors are guarded against damage from moisture and chemicals by special Polyseal® insulation systems.

*Trade-mark of General Electric Company

**SYNCHRONOUS MOTORS** with new and improved insulation systems operate reliably under many process conditions.

# Laykold® WEATHERCOAT
## protects exposed insulation

INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

*A new product: Mastic Weathercoat*, a bodied material, for use wherever economy demands the application of a *single*, thick layer.

*Write today for our free illustrated brochure, entitled "Laykold Weathercoat for Insulation Protection."*

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## *Equipment . . .*

### Automatic Plant Control With Electronic System

Unattended automatic control of chemical processing units is just one job of a new electronic supervisory control system.

Hundreds of tie-pin size transistors and

diodes comprise the brains of this new "solid-state" supervisory equipment. Performing the job of mechanical switches, these tiny electronic devices make possible practically foolproof, maintenance-free performance of any job calling for remote metering, monitoring or control.

With all applications, possibilities of human error are eliminated by automatic control, in addition to significant savings in reduced operating expenses.

Thinking components of solid-state supervisory equipment are transistorized cards that direct and receive operation messages to and from remote apparatus through a master station-remote station hook-up.

These plug-in cards, with no moving parts, take an impulse originated by a touch of a button or by a tape-controlled electronic connection and convert it into an outgoing code, direct it over the proper communication channel to the remote location, translate the code into another electrical impulse and direct that some action be taken.

When that action is accomplished—a switch closed, a circuit breaker tripped, or a valve partially opened—a reverse action takes place. The remote equipment initiates a report back to indicate what has happened. The answer appears in the form of a tiny light being illuminated, a change in a meter on the master control panel, or in a punched-tape record. General Electric Co.

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## REFRACTORY HAYDITE

**Makes Higher Heat Resistant Concrete**

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.

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# ENGINEERING NEWS

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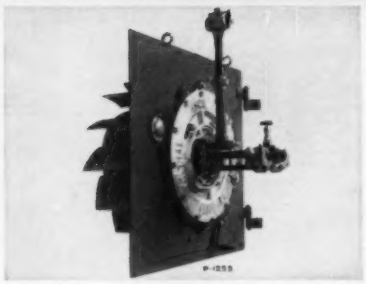


## Have You Investigated National Airoil Universal Register Units?

These efficient members of the National Airoil family of quality products are available in a wide range of models including the swing-type shown above.

This particular unit can be furnished with gas burners, ring or cylindrical type, and/or oil burners.

All vanes are variable independently of each other, and reversible from left to right turbulence (or vice versa) as a unit. The integral damper disc permits closing-off each individual burner tile to prevent air leakage on shut-down.

Engineering data on other National Airoil Universal Register Units from 60 to 500 gph are available upon request. Write for Bulletin 51A.

## Here's a Reliable Way to Prepare Heavy Fuel Oil for Combustion

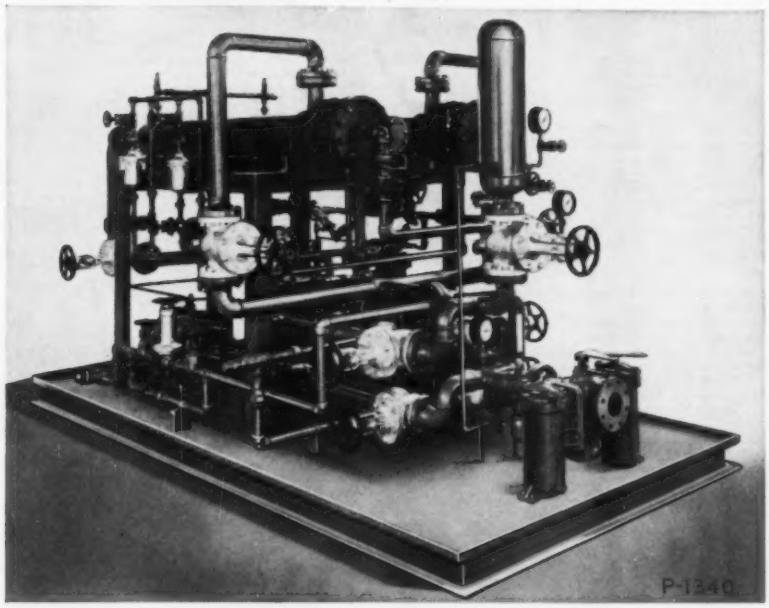
If your heating problem involves the preparation of heavy fuel oil for combustion, you'll want to investigate the advantages of National Airoil Fuel Oil Pumping and Heating Units.

For example, these reliable, efficient units provide these advantages:

- **even oil pressure and temperature**
- **valving easily understood by operators**
- **designed for a minimum pressure drop**
- **ease of maintenance**
- **space saving**
- **shipped complete ready for service connections**
- **less costly than on-the-job assembly**

National Airoil Fuel Oil Pumpingand Heating Units are available in single or duplex units, from 2 to 100gpm instandard or special models.

Bulletin 40 contains the facts. May we send you a copy?




## Do You Have These National Airoil Technical Bulletins In Your Library?

Whatever your industrial heating problem, you'll find a wealth of helpful information in these technical bulletins. Write for any or all of them today.

**BULLETIN No. 40. FUEL OIL PUMPING AND HEATING UNITS**

16 pgs. Here's the answer to problems involving preparation of heavy fuel oil for combustion. Single and duplex units, from 2 to 100 gpm in standard or special models.

**BULLETIN No. 28. AUTOMATIC PACKAGED FIRING UNITS**

4 pgs. Steam atomizing automatic firing units for oil and/or gas fuels. Standard unit capacities—from 200 to 830 boiler horsepower (7,200 to 30,000 lbs. of steam per hour). Larger units for special needs.

**BULLETIN No. 25. DUAL STAGE OIL BURNERS**

4 pgs. Data points out advantages when *both* mechanical and steam atomizing principles are incorporated in a single oil burner. 3 standard sizes are shown.

**BULLETIN No. 51A. UNIVERSAL REGISTER UNITS**

4 pgs. Data offered on full line of these quality National Airoil products with capacities ranging from 60 to 500 gph.

**BULLETIN No. 21. STEAM ATOMIZING OIL BURNERS**

16 pgs. Describes "SA" Burner for use where steam or compressed air is available for firing many types of industrial process furnaces. 5 sizes have rated capacities from 10 gph to 725 gph.

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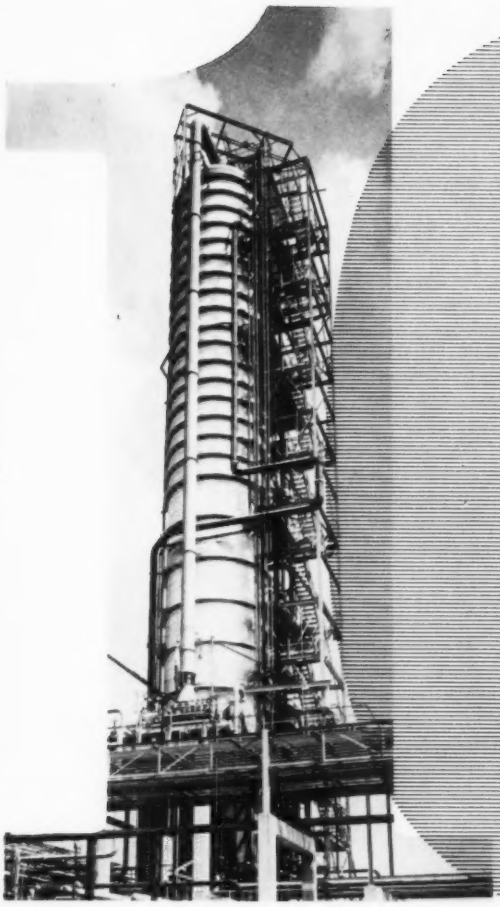

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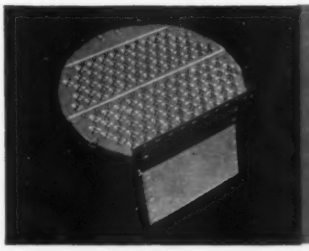

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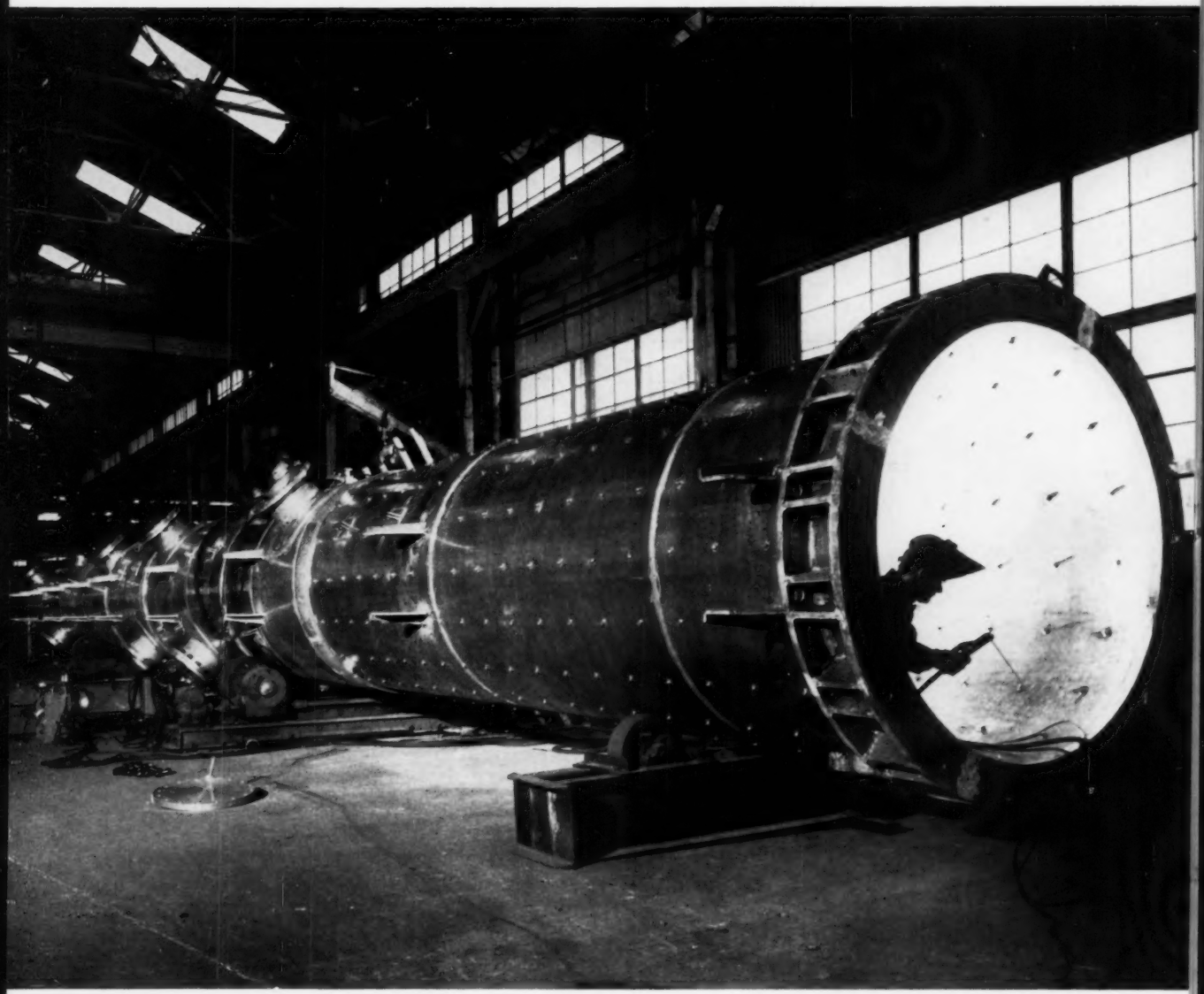

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